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CONSEIL PERMANENT INTERNATIONAL
POUR L'EXPLORATION DE LA MER
CHARLOTTENLUND SLOT – DANEMARK

JOURNAL DU CONSEIL

VOL. XVII · NO. 1

PUBLIÉ PAR LE BUREAU DU CONSEIL

RÉDIGÉ PAR
J. R. LUMBY

EN COMMISSION CHEZ
ANDR. FRED. HØST & FILS
COPENHAGUE

OCTOBRE 1950

Notice.

The Journal of the Council appears *three times a year*, and three numbers form a volume. It includes, in addition to general articles, reviews, and bibliography, the special papers previously issued in the series of *Publications de Circonstance.*

The Bureau regret to say that the increasing printing expenses have made it necessary to raise the annual subscription price to **30.00 Kroner** (+ mailing expenses) a volume, single copies are sold at Kr. 12.00. The subscription price includes, as formerly, if desired, a reprint of the bibliographical matter, printed on one side of the paper.

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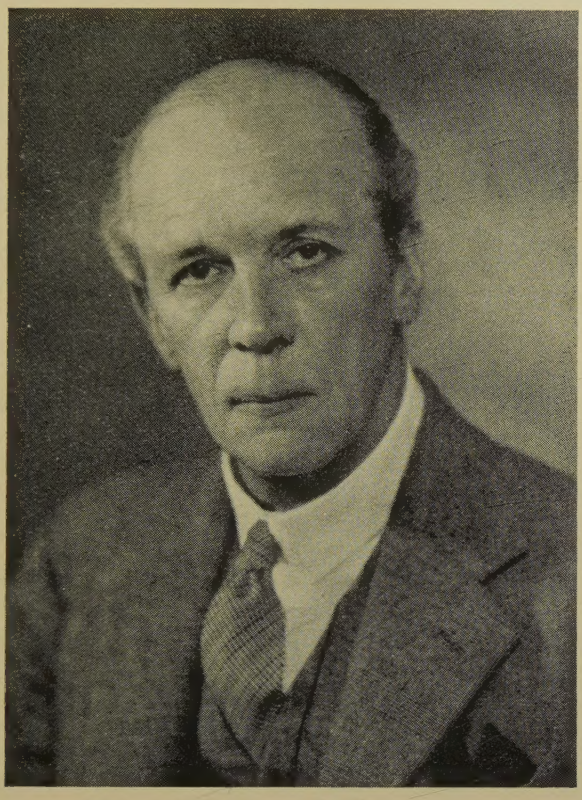


Henry Gascoyne Maurice.

1874—1950.

THE many friends of Henry Gascoyne Maurice, both at home and abroad, were grieved to learn of his death which occurred on 12. May 1950, after a good deal of suffering, following an operation early in 1949. His end, however, was peaceful, and both his devoted wife and son were present. His funeral took place at Marlborough in Wiltshire.

Henry Maurice was born on 24. May 1874 at Marlborough, where his father was for many years doctor to Marlborough College, and where Henry Maurice and his brothers were educated.

From Marlborough College, he passed as a scholar to Lincoln College, Oxford, where he took his degree, obtaining a second class in both Honours Moderations and Litterae Humaniores. He was subsequently called to the Bar by Lincoln's Inn in 1904 and then served for a time as assistant to the Director of Education in the County of Wiltshire, subsequently joining the legal branch of the Board (now the Ministry) of Education. Here he came under the influence of an outstanding Civil Servant, Sir Robert Morant (afterwards Permanent Secretary to the newly constituted Ministry of Health) and was appointed his Private Secretary. Later he became Private Secretary to the Rt. Hon. Walter Runciman, M. P., the President of the Board of Education, who brought Maurice with him when he became President of the then Board of Agriculture and Fisheries, to which a few years before the Fisheries Department had been transferred from the Board of Trade. It was at this time, 1912, that the late Walter E. Archer, Assistant Secretary in charge of Fisheries, reached the retirement age and Henry Maurice was appointed by Mr. Runciman to succeed him. He remained in charge of the Fisheries Department (his rank being raised later to that of a Principal Assistant Secretary, with the title of Fisheries Secretary) until 30. June 1938, when he retired from a post which he had held with conspicuous success. On his retirement he was appointed Vice Chairman of the White Fish Commission, whose activities came to an end on the outbreak of war at the end of 1939.

With his appointment to the Fisheries Department Maurice immediately addressed himself to the organization and development of his new department. Inshore fisheries were at a low ebb and an Interdepartmental Committee on Inshore Fisheries was set up to inquire into the whole problem. Fisheries Research also now came under the Fisheries Department and Maurice planned a comprehensive programme for the future, in which he was fortified by the recommendations of an Advisory Committee on Fishery Research, containing all the leading experts on the subject. With his new appointment he also assumed the role as a British Delegate to the International Council for the Exploration of the Sea, whose activities were soon to be brought to a virtual standstill by the outbreak of the first World War in 1914. Soon after the termination of hostilities in 1918, the Council resumed operations in an atmosphere which could hardly be described as anything but difficult, and it was now that Henry

Maurice brought his great qualities to bear upon the cause of the international co-operation which was the fundamental object of the Council ever since its foundation in 1902. Maurice succeeded to the Presidency in 1920, and although the Statutes required an annual election, he continued to hold that office until he retired at the end of June 1938. The devotion and affection which Maurice inspired on the part of all his numerous colleagues on the Council made his time of the Presidency a remarkable achievement. It was during those eighteen years that Maurice inaugurated the initial steps to deal with the overfishing problem and the international control of whaling where the question of depletion of stocks was beginning to become a serious problem. The London Conference of 1937 on overfishing, and the Whaling Conferences of 1937 and 1938, when the foundations were laid for much needed international control, were outstanding tributes to Maurice's magical qualities as a chairman, and no one who attended those conferences will forget the remarkable progress that resulted from his leadership. Just before he retired from the Presidency of the Council, Maurice was the recipient and so far the only recipient, at the hand of Prince Waldemar of Denmark, of the gold medal of the Johannes Schmidt Foundation for Oceanographical Research of Denmark.

On his retirement from active service, Maurice became Secretary of the Society for the Preservation of the Fauna of the Empire, a post which he retained up to the time of his death. He had been long associated with the Marine Biological Association at Plymouth, of which he was a Vice-President and he also threw himself with greater vigour into the affairs of the Zoological Society of London — he lived close to the Zoological Gardens in Regents Park, was a constant visitor, and had been a member of the Council for twelve years. In due course he became its President, at a none too easy period in the Society's history. He retired in 1948 and received the rare honour of the Society's gold medal, only awarded upon three previous occasions. Much of the development at the Zoological Gardens, and particularly at Whipsnade, opened in 1931, derived inspiration from Maurice's suggestions.

In 1916, Henry Maurice was made a Companion of the Order of the Bath, and for his services in the first World War he received the Order of Leopold from the Belgian Government. It was, however, a great disappointment to his friends that when several European countries sought to recognize his

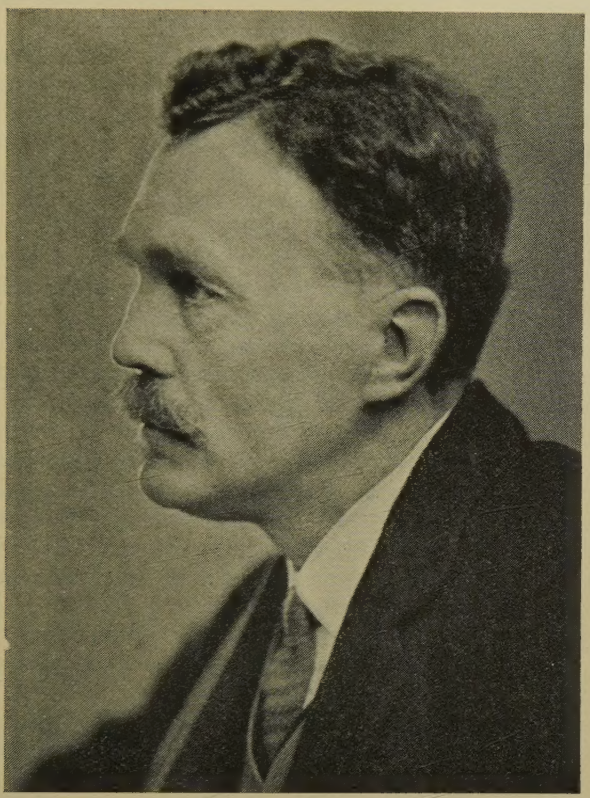
great services on the International Council, and in respect of international fishing problems generally, the prevailing regulations prevented his accepting their honours.

Henry Maurice was a British Civil Servant of the finest type and of the highest integrity. He was also the finest type of Englishman, lovable, suave, and with a rich vein of humour. He was beloved of his colleagues, and was quite fearless in putting forward and stressing what he believed to be the right point of view. He was at his best in arguing against the majority. Reference has been made to his unique qualifications as a chairman. His passing removes one who played an outstanding part in international fishing problems and their solution, and as his distinguished French colleague, Président Théodore Tissier, said on his retirement, when he was made a Président d'Honneur of the International Council, he will never be a stranger to the Council, with which his name is indissolubly linked.

Although not trained as a scientist, his work was among scientists and as the obituary in the London *Times* made clear, he was a field naturalist of no mean order and he wrote two delightful books, *Sometime an Angler* which appeared in 1947 and *The Wisdom of the Ass* published in 1948. — He was a keen fisherman and competent observer of birdlife.

Henry Maurice has gone to join the select few whose names in the world of Fisheries and Fishery Research, international and otherwise, will never be forgotten. He can ill be spared. The sincerest sympathy of all his friends goes out to his wife and son.

A. T. A. Dobson.



Walter Garstang.

1868—1949.

PROFESSOR Walter Garstang, who died at the age of 81 on 23. February 1949, appears to have been the last surviving member of that band of great pioneers who began the work of the International Council at the beginning of the century. He was one of the four British delegates sent by His Majesty's Government to attend the 1901 Conference at Christiania. He was director of England's share of the International Investigations from their beginning in 1902 till 1907, when he became Professor of Zoology at Leeds University. He was Scientific Advisor to the British Delegates at the International Council from 1902 to 1908 and for the same years

was Convenor of the International Committee on Trawling Investigations.

He was born on 9. February 1868, the eldest son of Dr. Walter Garstang of Blackburn and was educated at Blackburn Grammar School and Jesus College, Oxford. He graduated in the Honour School of Zoology, having studied under that great Challenger naturalist, H. N. Moseley, who was then Linacre Professor. As soon as he had taken his degree he was appointed Assistant to G. C. Bourne, the first Director of the new Plymouth Laboratory, and so joined its staff a week before it was actually opened on 30. June 1888. In 1895 he inaugurated the first of the Plymouth Easter classes for University students which, with their copies at other centres, have ever since played such an important part in the education of British Zoologists. During these early days at Plymouth Garstang wrote many papers on the morphology, bionomics, and distribution of marine invertebrates.

After a period when he was back at Oxford as a Fellow of Lincoln College, he returned to the staff at Plymouth as Naturalist in charge of Fishery Investigations. He became the moving spirit in the development of fishery science in England. He was clearly much impressed by Johan Hjort's pioneering research in Norway and his first paper in this period was an extensive account of Hjort's methods. Like Hjort he planned his work on a wide front and soon he was publishing papers on such different aspects of fisheries work as "The Surface Drift of the English Channel and Neighbouring Seas during 1897", "On the Variation, Races and Migration of the Mackerel" (1898), "On the Plankton and Physical Conditions of the English Channel" (1899), and on "The Impoverishment of the Sea" (1900).

Walter Garstang and Johan Hjort became great friends in those early years of the century as the work of the Council became established. There was something very similar about their lives apart from the fact that they covered almost the same period: Hjort was a year older and died a year earlier than Garstang. They both started with the intention of following their fathers' footsteps by studying medicine, they both turned to pure zoology at the University, both became attracted to marine biology and then took up fisheries work about the same time. When I was writing an account of Hjort's life for the Royal Society Obituary volume, I had asked Garstang for some notes about his early impressions of him; among those that he wrote for me, almost the last

thing he wrote a few days before he died, was the following which I have thought more appropriate to quote here: "Our first meeting, which I well remember, was at the Christiania Conference in 1901. Hjort was with his senior colleague Nansen and, as I was being introduced, he impulsively put his hands on my shoulders and, glancing at my hair and eyes, bluntly exclaimed 'But you are no Englishman: you are one of us'. He then proceeded to give what he said was the obvious Scandinavian etymology of my name, finishing with the remark 'A Stang was our last Norwegian premier'. My admittance to the Viking fraternity was soon endorsed by the veteran Danish biologist C. G. Joh. Petersen who came to treat the two of us playfully as his 'sons'; we certainly were his acknowledged and grateful disciples. At the conclusion of the conference Hjort, Heincke of Helgoland, and myself were left behind to collate the resolutions adopted and to revise the programme of investigations drawn up at Stockholm two years previously."

In 1901 the English and Scottish fishery departments were, as is still the case today, separate institutions; and the Fishery Board for Scotland had already begun its investigations well before the beginning of the century. The English department, a small branch of the Board of Trade as it was then, commissioned the Marine Biological Association to start its research for it as part of the international scheme; so it was that Garstang became Director of these investigations and established a laboratory at Lowestoft. With his assistants William Wallace, R. A. Todd, and George Atkinson, and the old research trawler "Huxley" he carried out from Lowestoft those investigations into the natural history of the plaice which laid the foundations of English fishery research. By extensive age determinations and measurements and particularly by liberating vast numbers of marked fish at different points (to be returned when recaught by fishermen) he studied the natural growth-rates and migrations of the fish in different areas. He realized how overcrowded the young plaice were on the nursery grounds off the Dutch coasts and how much more food there would be available for their growth on the Dogger Bank. He tried the experiment of transplantation. He caught and marked large numbers of young fish on the coastal banks; half of these he returned to the sea where he caught them and the rest he carried in tanks of sea water to be released on the Dogger Bank. When in time the marked fish were recaught it was found that those taken

to the richer feeding grounds had in two years grown twice as big as those left behind. Garstang had pointed the way to a farming of the sea, but he was before his time. In his Buckland Lectures in 1929 he returned to the subject and showed how such a transplantation on a large commercial scale could be made to pay, the increased yield of fish giving an ample margin of profit over the estimated cost of transport; but no nation was likely to undertake the cost of this, for all other nations would be free to reap the reward. While the nations work together in the science of the sea, the days of their co-operation in its exploitation are still far in the future; but one day surely the North Sea will be farmed in the way that Garstang showed: let us hope that his name will then be remembered.

Garstang was an individualist, a lover of freedom and independence, who resented what appeared to him to be interference in his scientific programme when official policy did not coincide with his own plans. At the same time as the newly constituted government Fishery Department decided in 1907 to take over the investigations from the Marine Biological Association he received a letter inviting him to accept the Chair of Zoology at the University of Leeds. It was a difficult decision for him to make; on the one hand he loved his marine work, on the other he felt he would never be happy if he was not entirely free to shape his own policy. Very reluctantly he resigned from his Directorship at Lowestoft and became Professor Garstang at Leeds.

After nearly twenty years of marine work he came back to more academic zoology and took up again the study of those problems which had fascinated him when he was an undergraduate at Oxford in the heyday of speculation as to the evolutionary origin of the different groups of animals. In his essay on "The Theory of Recapitulation" which he read before the Linnean Society in 1921 (published in the Society's Journal the following year) and in his presidential address to Section D. of the British Association in 1928 he put forward his revolutionary views on the influence of modifications in ontogeny upon the course of evolution. With them he helped to overthrow the influence of Haeckel's so-called "Biogenetic Law" which had dominated zoological thought for so long. Garstang coined the term *paedomorphosis* to apply to the evolutionary influence of larval characters upon adult organization. In two large papers "The Morphology of the Tunicata, and its bearings on the Phylogeny of the Chordata"

(*Quart. Jour. Micro. Sci.*, LXXII, pp. 51—187, 1928) and "The Morphology and Relations of the Siphonophora" (*Ibid.*, LXXXVII, pp. 103—193, 1946) he showed how paedomorphosis, by a process of neoteny, appeared to have played the leading role in the evolution of both the Chordates and the Siphonophora. I believe in this he made a profound contribution to biological theory.

He was a great teacher who by his infectious enthusiasm filled his pupils with a love of zoology; he was also their friend and delighted in taking part in student activities. I will quote from the obituary notice written in *Nature* by Professor L. E a s t h a m, one of his former pupils:

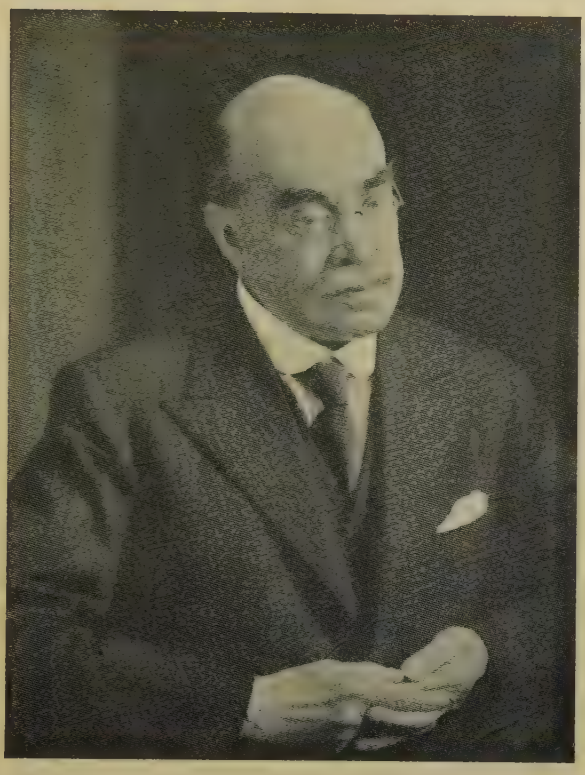
"Few who go from us will leave behind so much affection and such a sense of gratitude. It is inevitable that his students will remember G a r s t a n g for his perpetual youth and his genial kindness. They will think of their visits with him to the marine station which he established at Robin Hood's Bay; of teas in the laboratory at which he and Mrs. G a r s t a n g were generous hosts and at which the week's problems were discussed; and of their open house at Meanwood where all students were welcome."

There was yet that other important side to his personality, his strong poetic feeling which partly found expression in his "Songs of the Birds" which he recorded in verse and musical notation, but in addition provided a large number of poems of which only a few were published. I will end this brief account by giving his sonnet "Friendship" which was published in *Nature* in 1921 and which he reprinted on a Christmas card sent out to his old friends just two months before he died.

Were life an empty bubble blown by chance
To glitter, mount, and burst beyond repair;
Were mind illusion, fancies rich and rare
Mere exhalations, firefly effluence;
Or should this mood be but the spirit's trance
And one enduring Whole his Being share
By ordered gradients up the thronal stair
From atom fires to soulful radiance;
Be all philosophy beyond our ken
And nothing certain, — yet, as star draws star,
As bubbles meet and cling, electrons blend,
There sings a joy when friend meets parted friend,
Time's limitations yield, and past the bar
Life's transcendental portals ope again.

His very happy life and biological interests were shared by Miss L u c y A c k r o y d, of Newnham College, Cambridge, whom he met at the Plymouth Laboratory and married in 1895; she died in 1942 and they are survived by a son and five daughters.

A. C. Hardy.



Hugh Robert Mill.

1861—1950.

BUT yesterday, on leaving for the office, the business man took a glance at the sky and perhaps at the barometer in the hall, asking if he should take an umbrella or a coat this morning; today he receives a radioed, typed message as to the state of the weather at Cape Farewell or at Karachi, barometric pressure, wind direction and velocity, visibility, etc. Such changes in the collection of scientific weather reports all over the world and their dissemination to all interested people anywhere, to which he had himself contributed so much, are the highlights in the lifetime of the world-famous meteorologist,

rainfall expert, geographer, biographer, and bibliographer, who has recently passed on at the ripe age of eighty-nine, Dr. Hugh Robert Mill.

Although his direct contributions to the scientific study of sea fisheries may not be very numerous, there is no doubt many of his scientific investigations in various branches had some useful bearing on our special subject. He was from 1901 to 1908 one of the British representatives on the International Council for the Exploration of the Sea, and he had been, from 1884 to 1887, Chemist and Physicist to the Scottish Marine Station.

If the receipt of so many honours from home and abroad, Honorary Memberships, Medal awards, and so on is anything at all, it is an indication that, in his lifetime, his work on so many branches of his beloved geography and meteorology and his bibliographical and historical contributions, notably in the 1901 "Antarctic Manual", and in his historical article in Shackleton's "Heart of the Antarctic" and elsewhere, was fully appreciated. The Royal Geographical and Royal Scottish Geographical Societies, Royal Society of Edinburgh, British Association, and many other scientific bodies, Governmental and otherwise, all had in various capacities the benefit of his skill and advice on many problems. It is not easy to comprehend the industry and application over so long a lifetime that he was able to devote to his many interests. His was a shining example of the power of will over physical disabilities that could easily have excused him from such prolonged and trying labours. One finds it difficult to know which of his types of work and research to admire most. After many of his researches are back in their place in the history of geography and meteorology, and it may be said he helped to put them both on the map, his services to Antarctic history and travel will keep his name ever in the forefront of such contributors. His multiple Index in the "Antarctic Manual" of 1901 with its 878 bibliographical entries in all languages up to 1900 leaves us all in his debt, capped by his gift to the Scott Polar Institute of his priceless collection of Antarctic literature — a wonderfully characteristic touch. Of him it may well be said he "burned with passion for the South". His "Siege of the South Pole" is "a perpetual feast of nectar'd sweets", a model of what such a book should be. It would be impossible that all should agree with his criticisms of the various expeditions and leaders, but it is obvious that he brought together in accessible form much useful material of a historical nature and touched it with his own particular critical brush, and for this volume —

pity he was not able to undertake the extension to the Surrender or Conquest of the South Pole — we owe him a great debt of gratitude.

For his Speech of Laureation at the unveiling of the Shackleton Memorial delivered without a scrap of paper but faultless in style, phraseology, and selective appreciation, all were indebted to him, and his "Life of Sir Ernest Shackleton" serves to preserve in warm appreciative colours that wonderful personality whose name will for ever be associated with Antarctic achievement and endeavour. Every youth should read this book.

Although Mill parted at Madeira from Captain Scott and his companions on the National Antarctic Expedition ship "Discovery" in 1901 and had to return to Britain, it is certain that on his magic carpet Mill accompanied every Antarctic expedition since. No one was ever so completely steeped in everything Antarctic, and he kept up close contact with all who had been South whenever he could meet them and by means of his peculiarly personal and pleasing Christmas cards.

As an example of the triumph of determination over physical disabilities of a nature specially crippling to one of his interests, the life and work of Dr. Mill should provide for many years to come a brilliant and stimulating example to youth of this and every other country, worthy to rank with the best achievements and endeavours of those very men whose work in the Far South he has so nicely collected, annotated, and made available for all who care to read.

The International Council for the Exploration of the Sea mourns with so many other branches of Pure and Applied Science the passing of Dr. Hugh Robert Mill.

Ave atque vale.

W. C. Souter.
"Terra Nova" 1903—4, Aberdeen.

A Photo-Electric Cell Comparator for Colorimetric Analyses at Sea.

By

C. H. Roberts, B. A.,
Ministry of Agriculture and Fisheries, London.

THIS instrument was primarily designed to estimate phosphates in sea water, but it can also be used to determine any other constituent that can be measured colorimetrically, for example, silicates, dissolved oxygen, and ammoniacal nitrogen. It can also measure hydrogen-ion concentration.

Many excellent comparators are already available but these are usually better suited for use on land than at sea. Some are adversely affected by the motion of the ship, some are too fragile or too complicated, and some depend upon well smoothed electric current from mains. Special comparators for marine use have been designed by Graham (3) and Harvey (4).

The present instrument was designed with the following considerations in view:—

1. Accuracy. It should have an accuracy comparable with any of the instruments already used, and it should be possible to check its accuracy at any time by simple means. It should maintain its accuracy and sensitivity over long periods. It should be possible to compensate for the intrinsic colour of sea water and for the colour of the chemical reagents. It should be capable of being used by a person who is colourblind or whose perception of variations in depth of colour is not perfect.

2. Compactness. It should be self-contained and small enough to fit into the constricted space of a ship's laboratory.

3. Cheapness. It should be comparable in cost with any instrument that is commercially available.

4. Maintenance. It should be easy to trace faults and to rectify these with simple tools, even at sea.

5. Portability. It should be portable and light in weight so as to be easily moved from ship to ship.

6. Robustness. It should be strong enough to withstand frequent handling and the violent movements experienced at sea.

7. Simplicity. Its working principles should be simple and anyone should be able to use it after a short course of instruction.

8. It should be capable of estimating a wide variety of substances, thus economizing space in the ship's laboratory and saving the cost of buying a number of other instruments. One should be able to use it not only at sea but upon rivers, lakes, and estuaries.

Most of the desiderata have been met. For example, the cost is under £ 50, or less than one-third of the cost of some commercial instruments of comparable performance. The size of the instrument itself is 50 cm. × 15 cm. × 15 cm. The Weston Microammeter measures 17 cm. square by 7 cm. thick, and the Eel meter is even smaller. Both are light enough to be carried easily. The electric battery is the only heavy item. There are no complicated electronic circuits to go wrong, and in consequence the diagnosis and remedying of faults is relatively easy.

The first instrument has now been tested at sea for over two years and has given satisfaction. Since the first comparator was made, a number of others have been constructed, each incorporating certain small improvements upon its predecessors. These comparators have been used in the North Sea and the Arctic, and in the South Atlantic and Indian Oceans; one was recently completed for the "William Scoresby" for use in the Antarctic.

Working Principle.

The light from a motor-car headlamp bulb is focussed into a parallel beam by a Mangin mirror and shines through a long glass tube, which is sealed at both ends by optically ground glass disks which are fused on to the tube.

This tube is completely filled with a sample of sea water and a small amount of a chemical reagent, or a number of reagents, is added. These reagents have a specific reaction with the substance under test, and a colour develops, the intensity of which is proportional to the amount of the substance present.

As the light passes through the coloured solution some of it is absorbed and that which remains passes through an adjustable focal-plane shutter and an appropriate colour filter, and finally falls upon a selenium photo-electric cell of the "barrier-layer" type which generates a current proportional to the amount of light falling upon it (Fig. 1).

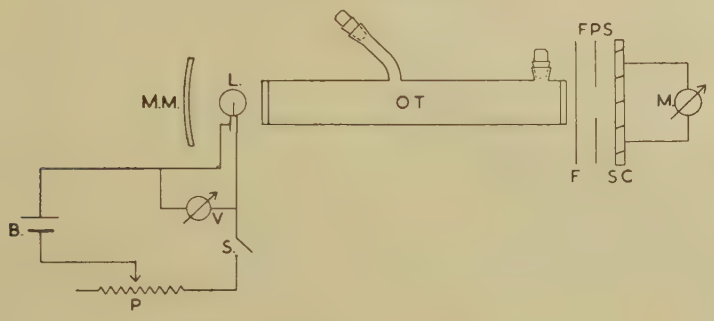


Figure 1. Layout of Comparator.

B. Battery.
P. Potentiometer.
S. On-and-Off Switch.
V. Voltmeter.
M.M. Mangin Mirror.
L. Lamp.
O.T. Optical Tube.
F. Light Filter.
F.P.S. Focal-Plane Shutter.
S.C. Selenium Cell.
M. Microammeter.

This current is measured by a microammeter which has been calibrated in terms of the substance being analysed. A typical calibration graph for phosphates is illustrated (Fig. 2).

The comparator is illustrated in Figure 3.

Details of Construction.

The source of light is a motor-car headlamp bulb of 12 volts and 12 watts. It is run at 11 volts so that a long life is ensured, but the bulb should be changed after 1000 hours' use and the instrument recalibrated.

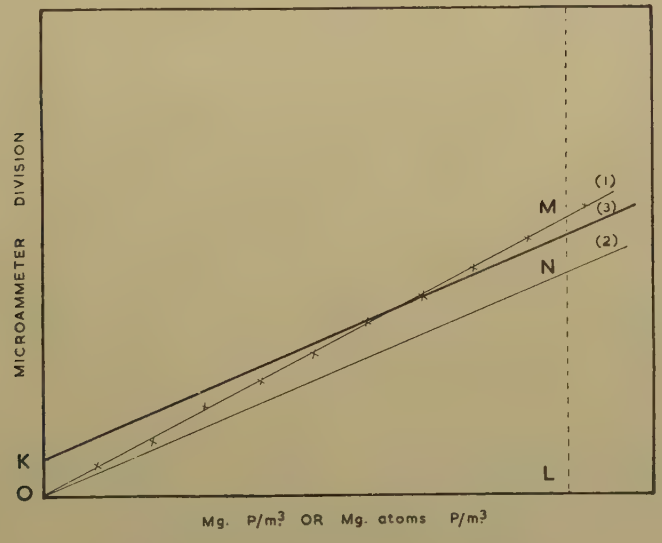


Figure 2. Calibration Graph for Phosphates.

The mirror is of the Mangin type and gives a parallel beam of light even without a condensing lens. The instrument can be used with the lid open, although this is not generally advised.

A 12-volt battery of about 70 ampère-hours capacity is used. As the current consumption is only 1 ampère the discharge is constant over fairly long periods. This is important in obtaining accurate results. The battery should be kept well charged.

The optical tubes were specially made by Messrs. W. J. Whilems Ltd. As all optical tubes vary slightly in their characteristics, it is essential that each tube should be calibrated individually.

The tubes are 250 mm. in length and contain a sea-water sample of only 60 ml. The side tubes on the optical cells have been added for ease of filling and emptying. A tube of 250 mm. in length is suitable for the estimation of phosphates, but with more strongly coloured solutions it may be necessary to dilute the solutions or to use shorter tubes. If shorter tubes are used, the focal-plane shutter and photocell should be moved nearer to the light source. Alternatively a short tube may be mounted in line with a longer tube containing distilled water. Some substances may give a very weak colour and it may be necessary to use longer optical cells. This may be done by using two of the 250 mm. tubes mounted in series.

The focal-plane shutter and photo-electric cell were made by Messrs. Evans Electroselenium Ltd. The cell is of the barrier-layer type, which converts light energy into electrical energy. No external source of power is needed. These cells, if properly protected from sea air, are very robust and long-lived. The intensity of the light falling upon the cell of the comparator is deliberately kept low to ensure that one gets a "straight-line" response and to protect the selenium cell against overloading. The cells are hermetically sealed to preserve them against sea air.

In the estimation of phosphates an Ilford tri-colour red or a Chance OR red filter is used. Other substances will need different filters, and some need no filters at all. Generally the colour of the filter will be complementary to that of the coloured solution under test. A green or blue solution needs a red filter, a yellow solution a blue filter, and a red solution a green filter. The most suitable filter is that which absorbs the most light and gives the best proportionality with different concentrations of solution.

It was decided that mirror galvanometers were unsuitable for use at sea, even though they are sensitive and accurate. To be used effectively, such galvanometers need a darkened laboratory and an external source of power. They are extremely fragile and are affected by the motion of a ship. On the other hand, microammeters need no external source of power, nor do they need a darkened laboratory; they are robust, and some types are almost unaffected by the rolling of a ship, even when severe. Suitable microammeters which are both robust and sensitive have recently become available at reasonable cost.

Two makes of meters have been tested, one made by Messrs. Evans Electroselenium Ltd., and one by Messrs. Sangamo Weston Ltd. The latter instrument measures up to five microampères and has a very robust and sensitive movement. The movement is magnetically shielded and is scarcely affected by the motion of the ship. A minor disadvantage is that the scale is linear, so that the calibration chart has to be made on logarithmic paper. The line of the graph slopes downwards from left to right. The Eel (Evans Electroselenium Ltd.) meter has the advantage of having a logarithmic scale and is specially designed to measure light-density variations. The graph line slopes upwards from left to right.

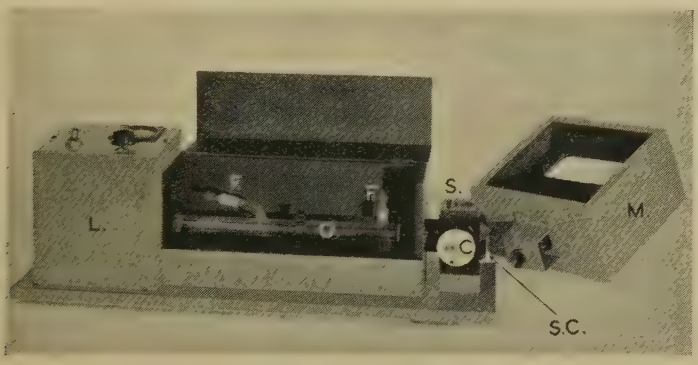


Figure 3. The Photo-electric Cell Comparator.

L. Lamp, mirror and controls.
O. Optical cell.
F. Filler tubes.
S. Slot for light filter.
C. Control for focal plane shutter.
S.C. Selenium cell.
M. Microammeter.

Experience at sea has proved that both instruments need protection against the corrosion caused by damp sea air. The microammeters have therefore, been enclosed in boxes which are both air and water-tight, and the electric leads are brought out through Belling-Lee hermetically sealed terminals. It is an advantage to pack a silica-gel drier into the water-tight box each time the instrument goes to sea. A switch is fitted to short circuit the movement of the microammeter when it is not in use.

In rough weather it may be necessary to place the microammeter on a gimbal table or to mount it in its own gimbals. Suitable gimbals may be purchased from yacht or marine stores, and one easily obtainable type is that made by the Primus Stove Company. The comparator itself is quite unaffected by the motion of the ship, however severe.

Calibration of the Comparator for Phosphates in Sea Water.

Details of the D e n i g è s method used by the International Council may be found in a number of works, for example, in "Recent Advances in the Chemistry and Biology of Sea Water" by H. W. H a r v e y.

See also Atkins (1), Denigès (2), and Robinson and Thompson (5).

The following method of calibration was developed by A. D. Perryman, of the Fisheries Department.

Procedure.

This comprises the determination of the error due to the colour produced by the reagents reacting between themselves (Steps 1 to 7), the actual calibration (Step 8), and the construction of the graph allowing for salt error (Steps 9 to 10).

1. Place the red filter in the slot, close the focal-plane shutter and switch on the light. By means of the variable resistance, adjust the lamp supply to 11 volts.
2. Fill the optical tube with distilled water, dry thoroughly, and place in the comparator. Switch on the microammeter and adjust the focal-plane shutter until the microammeter reads zero. Switch off the microammeter and light but *leave the shutter untouched.*
3. To 100 ml. of distilled water add 2 ml. of ammonium molybdate solution, followed by 2 drops of stannous chloride solution. Note the time of the latter operation.

As even the purest ammonium molybdate obtainable contains traces of phosphorus, a faint blue colour will develop. This colour takes about 10 to 15 minutes to develop fully and after 20 minutes may begin to fade.

4. After about 8 minutes, whilst the colour is developing, wash out the optical tube with about 10 ml. of the solution and then fill the tube completely with the remainder. Dry the tube thoroughly, and place it in the comparator with one end against the stop at the light-source end and with its filler tubes vertically upwards.
5. Switch on the light and microammeter and check the lamp voltage again at 11 volts.
6. After 15 minutes when the microammeter needle has settled down, take the reading of the microammeter, say x divisions.
7. Then, x divisions will be equivalent to the colour produced by the reagents in distilled water. Therefore, $\frac{x}{1 \cdot 19}$ divisions will be equivalent to the colour produced by the reagents in sea water, using Harvey's salt-error factor of 1·19.

As x may vary with different batches of reagents it should be redetermined whenever new ammonium molybdate is used.

8. Now set the microammeter to zero, using the sample of distilled water + reagents. Calibrate the instrument using various solutions of standard phosphate. Suitable concentrations are 10, 20, 30, 40, 50, and 60 mg. of P per cubic metre, or $^1/_4$, $^1/_2$, $^3/_4$, 1, $1^1/_4$ $1^1/_2$, $1^3/_4$, and 2 mg. atoms of P per cubic metre.
9. Plot a graph (Fig. 2) of the microammeter readings vertically

against the concentration of P in mg. or mg. atoms per cubic metre horizontally.

This graph (1) should be linear and the line of closest fit through the origin should be drawn.

10. Select any vertical ordinate, say LM, and diminish its height in the ratio 1:1·19, to LN. Join N to the origin O by a straight line (2). This is a correction for salt error.

Now, through the point K, where $OK = \frac{x}{1 \cdot 19}$ divisions, draw a line parallel to (2). Thus the error due to the reagents is accounted for. This line (3) is the Calibration Graph.

Much of the tedium of making up standards and checking calibrations can be obviated by the use of permanent colour standards such as are described in Snell's "Colorimetric Analysis" (6), or, better still, by the use of permanent coloured glass standards such as can be obtained from the Tintometer Company, Salisbury, England.

Estimation of Phosphates in Sea Water.

The filtered sea water sample is run into the optical tube which is dried and placed in the comparator. The focal-plane shutter is adjusted until the microammeter reads zero, and then left in this position. This compensates for the colour intrinsic in the sea water.

Meanwhile 100 ml. of the same filtered sample is treated with ammonium molybdate and stannous chloride. The optical tube is then filled with this solution and placed in the comparator. When the blue colour has fully developed after 15 minutes the reading of the microammeter is taken and the concentration of P is read off the graph (3).

Care of the Instrument and General Operational Notes.

The comparator should be calibrated regularly, say about once a month. If a new optical cell is fitted or the lamp changed, or if the microammeter is severely jarred, the instrument should be re-calibrated.

When not in use and, in particular, when travelling, the movement of the meter should be short-circuited. Particular care is needed when cleaning the optical cells because any fingerprint, or drop of water, or a piece of lint upon the optical disks may give rise to error.

In the design of the instrument much help was given by Mr. Sutcliffe, of the Government Laboratory, who freely put at our disposal the excellent facilities of the Laboratory's workshops and the advice of the technicians. Mr. Maycock, of the Government Laboratory, helped in the preparation of the standards..

Particular appreciation is due to Mr. Perryman of the staff of the Ministry of Agriculture and Fisheries. Many of the constructional and operational details are due to his suggestions and he made the

comparators in the Ministry's laboratory and the workshops of the Government Laboratory. In addition to this work he calibrated the instruments and helped to test them at sea in the "Sir Lancelot" and the "Ernest Holt".

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Echo-Sounding Experiments on Fishing Gear in Action.

By

Henry Wood and **B. B. Parrish.**

THE echo-sounding apparatus on F. R. S. "Clupea" (Hughes M. S. XII), besides recording shoals of herring etc., has given also very good echo-traces from such small objects as the Nansen-Petterson water-bottle, the bathythermograph, the head of a large cod which had been thrown overboard, and other relatively small objects. It was considered that an instrument of such sensitivity could also provide information on the behaviour of fishing gear in action, to measure, for example, the height of the headline and other parts of a trawl above the sea bottom. If successful tests could be made it was obvious that this echometer could have many useful applications in addition to the location of fish shoals and the sea bottom.

In February 1949 a short series of experiments was undertaken (by H. W.) in the Firth of Forth using the "Clupea" to make echo-sounding records of F. R. S. "Explorer's" trawl in operation.

The results were encouraging and similar experiments were later carried out (by B. P.) to obtain echograms of the "Scotia's" trawl, and also the "Fairfree's" special trawl.[1]) The senior writer also took an opportunity to make a series of echograms of the Larsen Floating Trawl, as used by the experimental vessels of the Herring Industry Board, "Silver Scout" and "Silver Searcher". Unfortunately these last trials had to be suspended abruptly through the diversion of the vessels to other methods of fishing.

Such experiments will be continued. The present paper is primarily to indicate the possibilities the echometer has for such work.

[1]) Operated by Messrs. Chr. Salvesen of Leith; see p. 33 and Lockridge 1950.

Apparatus.

The echometer — Hughes M. S. XII — used in the experiments, operates at a sound frequency of 14·5 Kc./s. It records on two depth phases, up to 130 ft. and 130 fm. respectively, with corresponding stylus speeds of 266 and 44 revolutions per minute. In the trials about to be described, only the shallow phase was used as it was important to obtain traces on the largest possible scale. This, of course, limited experiments to depths of less than 22 fathoms.

The trawl used by the "Explorer" was attached directly to the otter boards. Its more important dimensions were:—

Headrope	112 ft.	Top wings	43 ft.
Footrope	58 ft.	Square	16 ft.
Bosom	22 ft.	Baitings	25 ft.
Trawl boards	9 ft. 6″ by 4 ft. 3½″.	Belly	27 ft.
		Cod-End	25 ft.

In the initial experiments 12 metal floats were attached to the headline of the trawl, 4 being attached to the middle of the headline and sets of 4 at points where the square joins the wings. The purpose of these floats was to ensure a recordable echo, but as the experiments progressed it was found that floats were unnecessary as echo-traces were obtained from practically all parts of the trawl.

The Experiments with "Explorer's" Trawl.

It was arranged that, when the "Explorer" had shot her gear and was steering on a fixed course, a towline should be passed from the "Clupea" to enable her to keep good station astern of the "Explorer".

The first trials were made on 15. February on grounds 8 miles SE. of Kirkcaldy. Weather conditions unfortunately were very unfavourable, and with a SW. wind, force 5—6, towing was out of the question. The "Clupea" failed to find any trace of the trawl, and for two very good reasons. Firstly, the "Clupea" had misjudged her distance from the "Explorer" and had kept station ahead of the trawl. Secondly, the pitching and rolling of the „Clupea" caused so much aeration under the hull that transmissions from the oscillator and returning echoes were being almost continuously intercepted.

On the following day, 16. February, trials were resumed on the same grounds, but although weather conditions had improved, they were still too boisterous for the "Explorer" to tow the "Clupea". As an alternative, a pallet was floated astern of the "Explorer" on a length of line corresponding with the amount of warp out. This proved a very satisfactory guide indeed, and a very good trace was obtained in the neighbourhood of the pallet (Fig. 1). Maximum recorded height of the net above the sea floor was about 7 feet. There was no trace of the footrope. It was observed that when the ship sheered to port or starboard height invariably diminished towards the selvages. Most of the records made on this occasion would appear to have been confined to the neighbourhood of the headrope and the square.

The experiments were resumed on 17. February and with much more favourable weather, it was possible to pass a tow-rope from the "Clupea" to the "Explorer". When contact had been made with the trawl, the towline was veered 2 or 3 fathoms at a time with a view to covering the whole trawl as far as the cod-end. When contact was lost, the towline was hauled in slowly and the echo-survey of the trawl was made in the reverse direction until traces from one of the warps appeared.

In towing, the "Clupea" was sometimes sheered gently to port and starboard with a view to getting some clue as to the part of the trawl being surveyed. Naturally echoes would be obtained from the neighbourhood of the baitings, cod-end and near the ends of the wings for a much shorter time than at the middle or the mouth of the trawl.

The traces obtained on this occasion were easily the most successful and instructive.

On the 18th the experiments were carried a stage further when the metal floats were removed from the headline. Although weather conditions were quite favourable, trials did not go as smoothly as on the previous day. Considerable time was taken to pass the towline from the "Clupea" to the "Explorer". At one point the "Explorer" went into water which was too deep to be recorded on the shallow phase of the echometer. The "Clupea" did not succeed in keeping good station but sheered rather acutely, with the result that contact could not be maintained with the trawl for long, and there was a tendency for the strains on the tow-rope to become rather unequal, with the result that the "Clupea" would surge ahead and then drop back, causing difficulty in identifying with assurance any of the traces.

The experiment, however, proved that floats were not necessary in order to ensure an echo. The maximum height recorded was about 5 or 6 feet, but one could not be sure whether this was at the headline or some other part of the trawl.

Discussion ("Explorer").

On 16. February it was uncertain what part of the trawl was recorded. There is certainly no trace of the footrope or of the warps, and when the speed of the "Clupea" was accelerated slightly the trace was lost. It is almost certain, therefore, that the traces or most of them were from the neighbourhood of the headline and square. The maximum height above the sea floor was 7 feet as determined on the spot by the foot-scale on the recorder. As the traces may have come mainly from the metal floats which were fastened close to the top of the headline, it may be necessary to accept the true height of the headline at its centre as being about 6 feet (Fig. 1).

On the 17th, when the "Clupea" was towed by the "Explorer", it was possible to exercise better control of the "Clupea's" station and to alter it in relation to the trawl by veering or shortening the towline.

The first traces — seen at the bottom of the records made on the

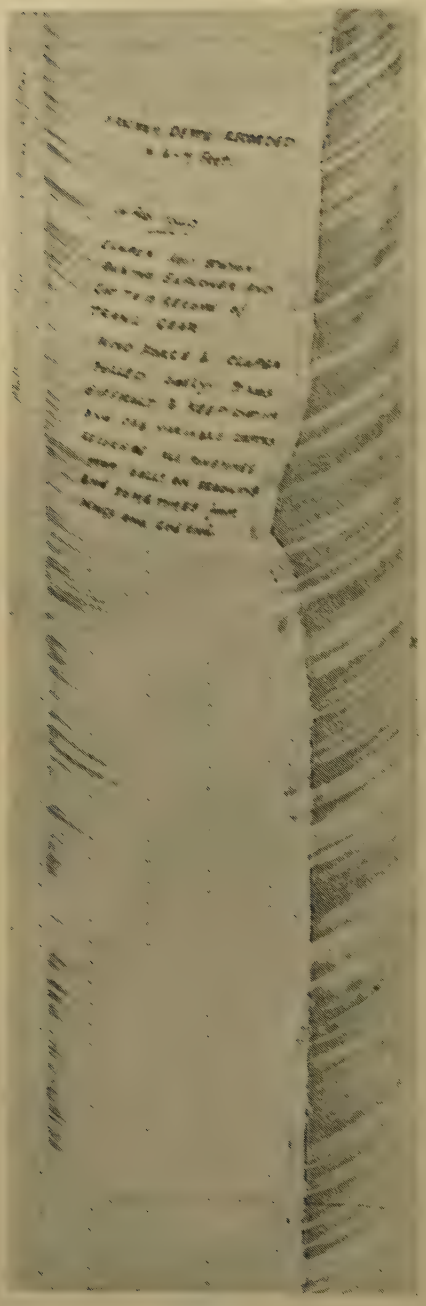

Figure 1.

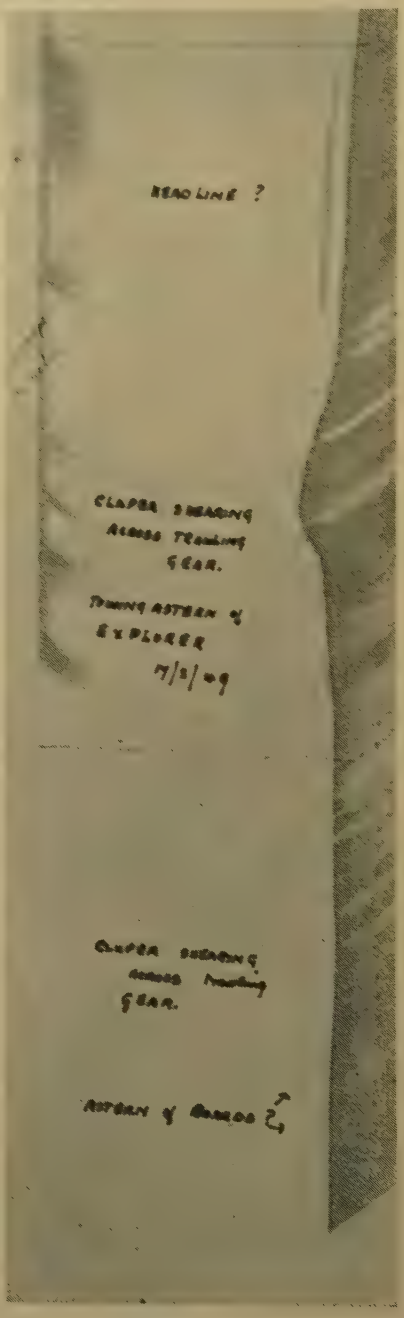

Figure 2.

"Clupea" Echo-Sounding over "Explorer's" Trawl.

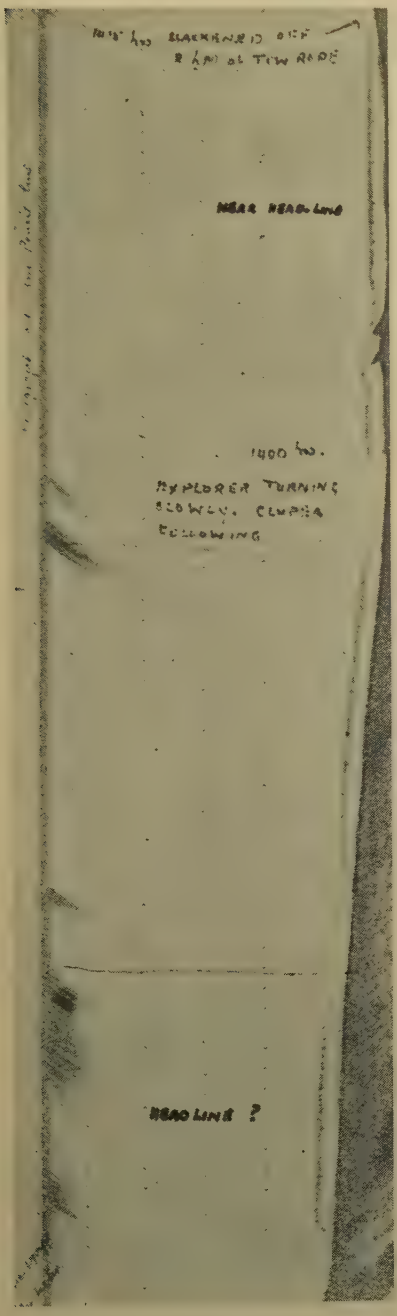

Figure 3.

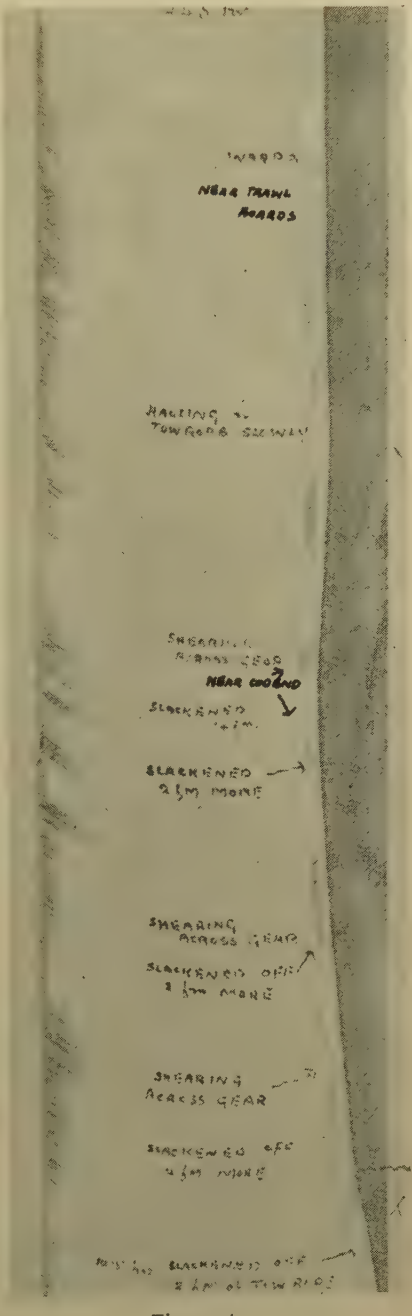

Figure 4.

"Clupea" Echo-Sounding over "Explorer's" Trawl.

17th — cover a small area and appear to have been from the wings slightly astern of the otter boards (Fig. 2).

As more towline was allowed and the "Clupea" was made to follow a gently zig-zag course, the area of the trace was increased and maximum depths of 6 or 7 feet were recorded.

Later, when the "Clupea" was kept on a fairly steady course, traces were obtained from the roof of the net and the footrope — see part marked "Headline?" — showing that the "Clupea" then was actually astern of the headrope. At this point the roof of the net was about 5 or 6 feet above the sea-floor. It is interesting to note that the footrope sometimes rose a little off the bottom. These three points are illustrated in Figure 2.

Figure 3 illustrates the behaviour of the trawl crossing a small submarine ridge (note the footrope rising above the sea floor). The traces show a reduction in height towards the selvedges. This is clearly apparent at the bottom of Figure 4. It would appear therefore that the roof of the net is *slightly arched* with a maximum height of about 6 feet. The converging flow into the mouth of the trawl from the otter boards would undoubtedly tend to lift the roof of the net and possibly the headline. Traces from the neighbourhood of the baitings and cod-end are to be seen in the upper part of Figure 2 and in the lower part of Figure 4.

The final item, at the top of Figure 4, shows the warp near its place of attachment. At this point it is clear that the "Clupea" had surged ahead, increasing the height of the echo-trace of the warp above the bottom and had then dropped astern a little, causing a corresponding decrease.

The results obtained in this experiment indicate clearly that valuable information can be obtained concerning the behaviour of trawl gear in operation. In addition to that regarding the height of the various parts of the trawl from the sea bed, some of the traces recorded from near the mouth of the trawl showed clearly that the underside of the net was clear of the bottom. They suggest therefore that for part of the period of towing the groundrope was rising from the sea bed. This evidence is of particular interest in the light of results obtained from comparative fishing experiments between the "Explorer" and the research vessel "Sir Lancelot", which showed that the "Explorer's" gear was the more efficient for catching roundfish, whereas the "Sir Lancelot's" caught larger quantities of the forms living closer to the sea bed (M a r g e t t s, 1949; P a r r i s h, 1949). In these experiments the "Explorer" used gear with a light groundrope and bosom, similar to that used in the echometer trials, whereas the "Sir Lancelot" used heavier gear. It is probable therefore that the differences in the catching capacities of these two gears, particularly for flatfish, can be explained in part by the tendency for the "Explorer's" gear to skim lightly over the sea bed, and at times to fish slightly above it, and for the "Sir Lancelot's" to be in more constant contact with it.

Suggestions for Future Experiments.

The experiments would be well worth repeating, especially without floats on the headline.

It is useful to have a pallet streamed from the towing ship to act as a guide to the recording vessel, but it is recommended that the pallet should be about 10 yards ahead of the estimated position of the trawl, so that the steersman on the recording vessel can always keep it in view and have freedom to manoeuvre his ship without incurring the risk of fouling the propeller.

A towline between the vessels has certain advantages; at the same time it is important that the recording vessel should be made to sheer gently across the gear, otherwise violent forward surges will take place, especially when the towline is 70 or 80 fathoms long.

With the present apparatus, experiments of this nature can be made only at depths not exceeding 21 or 22 fms.

Quiet weather, free from excessive sea disturbances, is essential and the best results are likely to be obtained on a fairly uniform sea-floor.

Survey of Trawl used by F.R.S. "Scotia".

In view of the satisfactory results obtained in the first trials, it was decided to repeat the experiment with the trawl used by F. R. S. "Scotia". This experiment was carried out on 12. April 1949, with the "Clupea" again acting as the recording vessel.

The "Scotia's" gear differed from the "Explorer's" in having much smaller dimensions, whilst having relatively heavier groundropes. It was of particular interest to determine whether the recording vessel could be maintained in position over a trawl of this size and to give satisfactory records of its behaviour.

The net used had the following dimensions:—

Headrope	32 ft.	Top wings	12 ft.
Footrope	20 ft.	Lower wings	25 ft.
Bosom	8 ft.	Square	10 ft.
Trawl boards	4 ft. 6″ by 2 ft. 6″.	Baitings	10 ft.
		Belly	10 ft.
		Cod-End	8 ft.

Twenty-foot wire legs were used between the trawl boards and net, and six floats were spaced at equal intervals along the headline. A soft bosom of 2″ wire wound with rope was used, but the groundropes were made of 2″ wire bearing thick rubber disks.

The procedure adopted in this experiment was similar to that described for the "Explorer" trials. The "Scotia's" trawl was first shot in water of approximately 10 fathoms depth, and when it was being towed on a straight course a towline was passed to the "Clupea". A float was then streamed from the "Scotia" and towed approximately 6 fathoms in front of the estimated position of the trawl so as to act as a guide to the helmsman on board the "Clupea".

The towline was first hauled in until the "Clupea" was level with the float and sounding was commenced on the shallow phase of the echometer using ¾ to full gain. The towline was then slackened gradually, with the "Clupea" sheering slowly from side to side until the first trace of the trawl was obtained. A full longitudinal survey of the gear was then carried out, the towline being slackened slowly until the "Clupea" fell astern of the cod-end of the trawl, after which the towline was slowly hauled in.

This survey was repeated with the "Scotia" using three towing speeds, represented by engine speeds of 60, 70, and 75 revs./min. respectively.

Traces of the trawl were obtained on each of the three surveys carried out during the experiment, but the small dimensions of the trawl, and the presence of strong westerly winds at the time of the experiment, made it difficult for the recording vessel to be kept over the gear. Consequently only short-duration traces were obtained from each part of the net. It was found, however, that by sheering across the gear it was possible to obtain measurements of the heights of the different parts of the net from the sea bed. Furthermore, there was no change in the heights recorded at the different towing speeds and even at the fastest speed, there was no indication of the trawl rising from the sea bed. The maximum heights measured for the different parts of the trawl were as follows:—

Headrope and/or Square	4 ft.
Baitings	3½ ft.
Cod-End	2½—3 ft.

Discussion ("Scotia").

Whilst it is evident from the results of the experiments with the "Explorer's" and "Scotia's" trawls that the echometer can be used to give accurate measures of the vertical distance between the sea bed and the headline of the trawl, it is not so easy to obtain with it the other important measure, the width of the mouth. This measure is necessary before the area of the catching surface can be calculated. An attempt was made in the experiment with the "Scotia's" trawl to obtain this measurement by attaching floats, on 15 fathom lengths of thin rope, to each of the trawl boards, with the object of their being visible at the surface and their distance apart being measured by observers aboard the "Clupea". This proved unsuccessful, however, since the floats were not visible at the surface, and the experiment was discontinued in view of the unfavourable sea conditions. Instead, a rough measure of the angle between the warps at the towing block was made, and the distance between the boards was estimated. The angle between the warps was approximately 10° which, with 50 fathoms of warp between the trawl boards and towing block, gives an estimated distance between the trawl boards of 52 ft. This represents 72 % of the total length of the headline and wire legs. These values give an estimated area of

about 140 square feet for the rectangular surface area of the mouth of the "Scotia's" trawl, when fishing.

Echometer Records of Trawl Fishing Pelagically.

A further opportunity to test the use of the echometer for observing trawl behaviour was afforded during the operational trials of the trawler "Fairfree", with the kind collaboration of the owners, Messrs. Chr. Salvesen and Co., Leith. These trials took place in the Clyde estuary on 8. August 1949. The recording vessel on this occasion was M. V. "Calanus", which was kindly lent for this test from the Scottish Marine Biological Association's Laboratory at Millport. This vessel was equipped with a Kelvin and Hughes M. S. 21 echometer. Dr. Orr and Dr. Barnes of the Association's Staff collaborated with the second writer (B. B. P.) in this programme.

The trawl used aboard the "Fairfree" differed from the normal otter-trawl in being composed of two subsidiary trawls with 90-foot headlines, joined together in the centre, and having special buoyant spreading devices in the form of "parotters". Heavy metal bobbins were attached to the footropes of the trawls to act as sinkers (Lockridge, 1950).

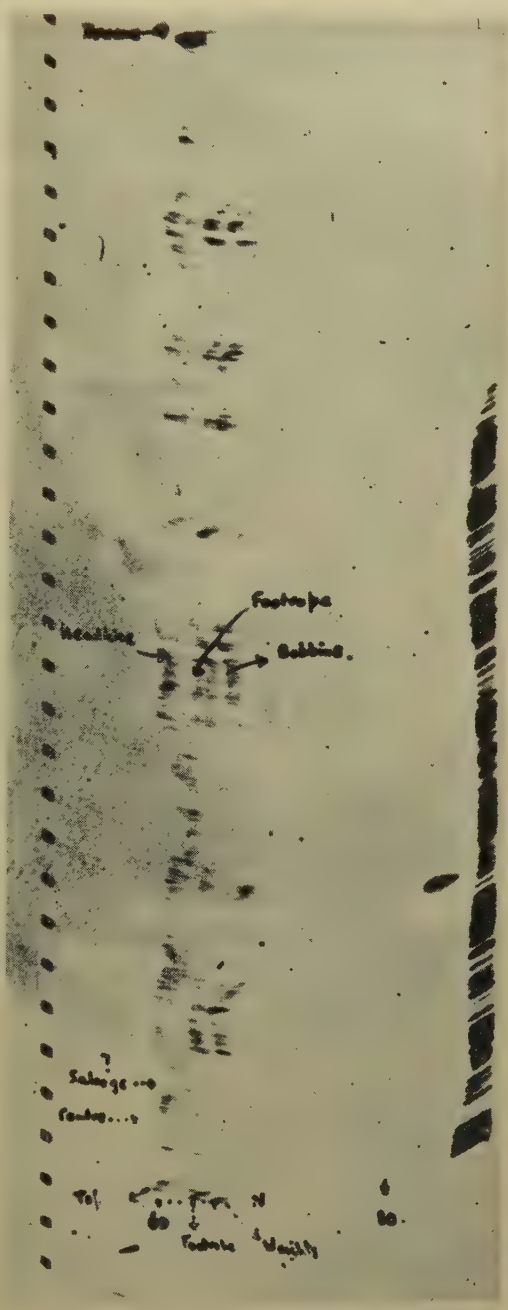

Figure 5. "Calanus" Echo-Sounding over "Fairfree's" Trawl. Fishing Pelagically.

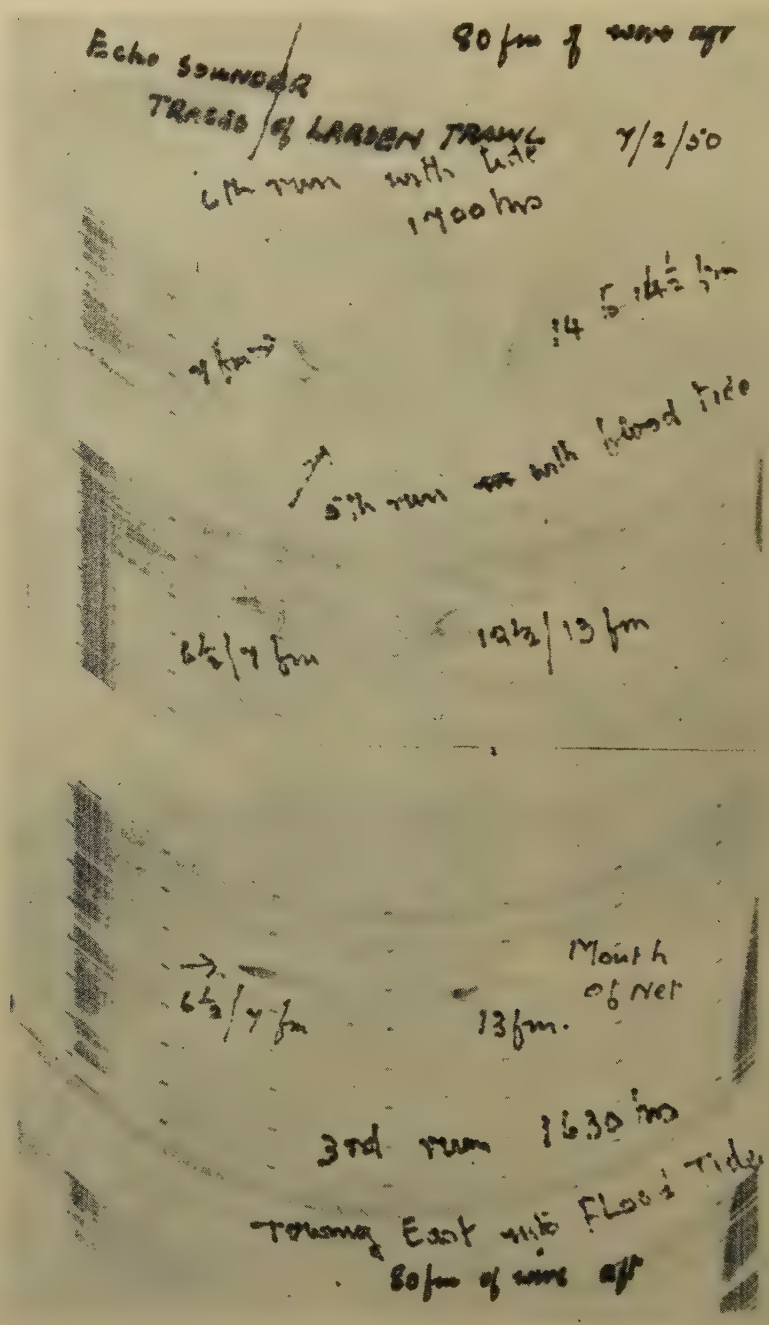

Figure 6. "Clupea" Echo-Sounding over Larsen Floating Trawl.

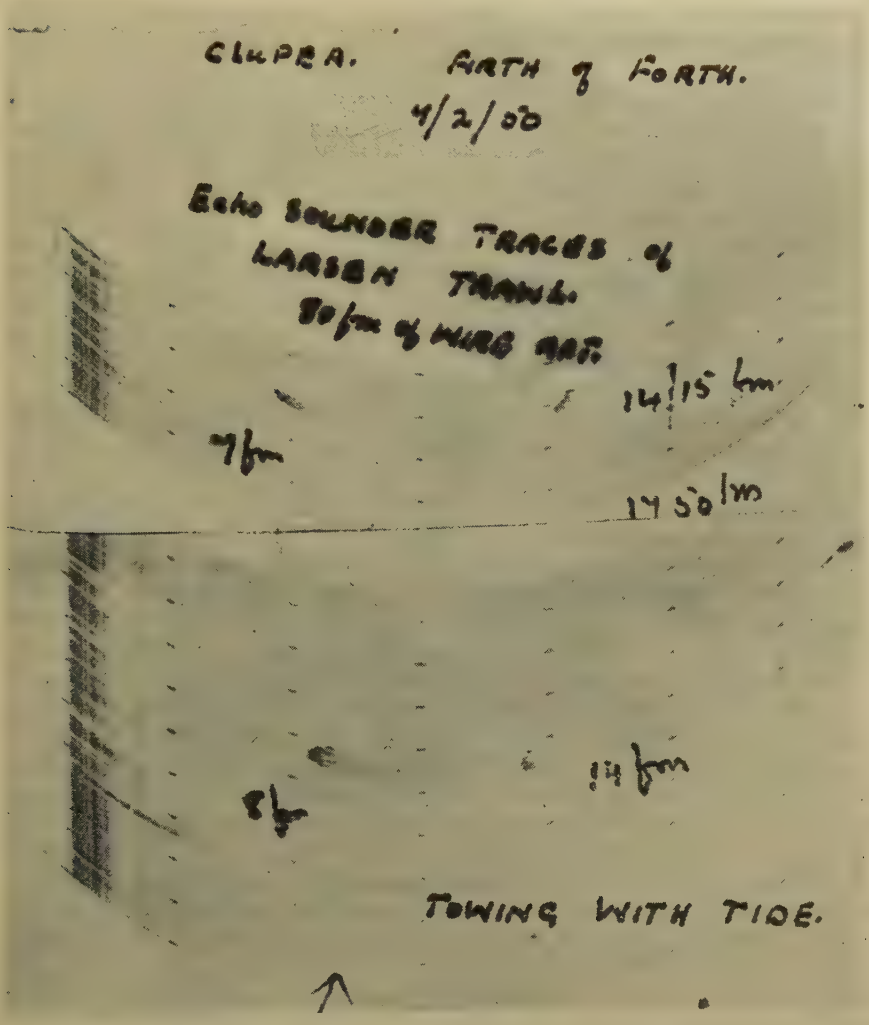

Figure 7. "Clupea" Echo-Sounding over Larsen Floating Trawl.

During these trials, the "Fairfree's" trawl was shot, and sufficient warp was paid out to carry the net to approximately 10 fathoms below the surface. The "Calanus" then steamed up over the trawl, using the echometer on the shallow phase and with approximately full sensitivity. Good records from the region of the mouth of the trawl were obtained, from which the headline, groundropes, and bobbins could be distinguished (Fig. 5). The distance between the headline and groundropes, measured on the trace, was 9 feet, which was the height expected by the net designers.

The Larsen Floating Trawl Echograms.

In February 1950 the "Clupea" took the opportunity of making a few echogram records of the Larsen Floating Trawl, with the kind collaboration of the Herring Industry Board. This trawl was operated by the "Silver Scout" and "Silver Searcher", experimental fishing vessels of the Herring Industry Board, which were then engaged in a survey of the Forth winter herring fishing grounds.

It had been planned to make a series of observations to determine the depth of the net with different lengths of towing warp. Initial trials were made on 2. February with 80 fathoms of warp in addition to the bridles, which measured about 20 fathoms. Unfortunately stormy weather intervened and before the experiments could be resumed the "Silver Scout" and "Silver Searcher" had to be detailed for other duties, so that further trials had to be abandoned.

The trawl, according to specification, measures 7½ fathoms square at the mouth. The headline is furnished with a series of floats, metal in this case, and the footrope carries a number of small lead sinkers.

The procedure was for the "Clupea" to steam at half speed over the gear and between the towing vessels on a course parallel with theirs. The gear was towed both with and against the current, which was running at a speed estimated at 1 to 2 knots at the surface. Results are reproduced in Figures 6 and 7.

Echo-traces appeared almost simultaneously from the neighbourhood of the headline and footrope, those from the headline being the more vigorous. The records show that the headline was maintained at a level between 6½ and 8 fathoms from the surface, while depths recorded for the footrope ranged between 12½ and 14½ fathoms. Thus the distance between headline and footrope at approximately their mid-points fell little short of the maximum vertical dimensions of the mouth of the net.

Differences in depth of the net when towed with or against the tidal stream amounted to about 1 to 1½ fathoms, the records indicating a slight upward lift when towing into the stream.

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A Simple Otolith Cutter.

By

A. D. Perryman,

Fisheries Research Laboratory, London.

THIS instrument was designed to meet the long-felt need for a simple, inexpensive, and speedy device for the cutting of cod and other heavily calcified otoliths used for routine age analysis. Formerly, otoliths were often read after being snapped transversely between thumb and forefinger. With difficult specimens polishing with a fine abrasive was then necessary. However, few otoliths broken in this manner presented uniformly flat surfaces suitable for photographing, and the need for a mechanical cutter emphasized itself.

One such instrument has been described by Å. Vedel Tåning (1938). The method involves embedding the otoliths in plaster of Paris, and this having set, grinding them down to the required section with carborundum. The preliminary operations in this method, however, take up considerable time although the actual grinding may be a matter of seconds.

It was felt that an instrument was needed which would cut an otolith and have it ready for immediate inspection or photographing within a minute or two. The cutter now described achieves this.

The initial problems encountered were the choice of a suitable cutting tool and a means of holding the otoliths steady during the cut. First, a jeweller's piercing saw was tried, but blades thin enough were not obtainable. Experiments were then carried out with thin wheels of carborundum and bauxilite. These were too coarse and generated too much heat, resulting in charring and often splintering of the otoliths. Finally, a jeweller's circular saw, 5/1000 of an inch thick, of hardened steel, was found to be successful. This saw was most effective in that being so thin, it wasted very little of the otolith.

Methods of holding the otoliths by setting them in Canada balsam and similar substances were discarded because of the time involved. A quick-release holder was devised from an ordinary bulldog paper clip.

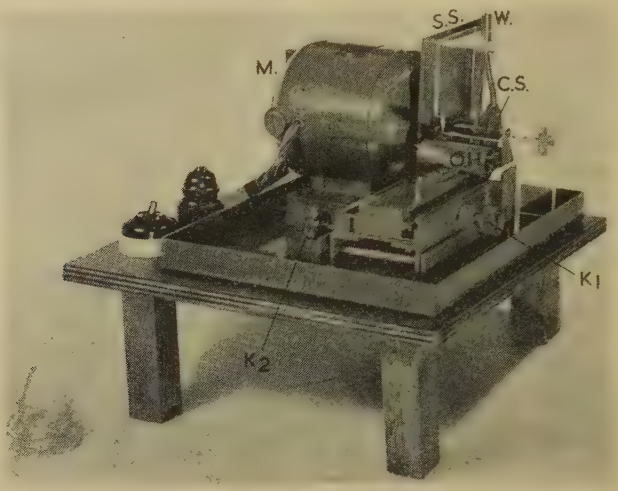

Figure 1. The Otolith Cutter.

Owing to the charring of otoliths under heat, a water cooling system was found necessary, and this proved an added advantage as the flowing water washed away the otolith sawdust.

The otolith cutter (Fig. 1) consists of an electric motor (M), on the shaft of which is firmly mounted a fine jeweller's cutting saw (C. S.). The otolith holder (O. H.) can be moved up to the spinning saw by means of a rack and pinion worked by an adjusting knob (K 1). The sliding base to which the holder is fixed can be traversed by a knob (K 2) so that thin sections of otoliths can be taken when required. The saw is enclosed for safety in a hinged perspex box. The water feed (W.) ensures cooling during the operation. The waste water is collected in a sloping tray and runs away through an outlet beneath the baseboard. A screen (S. S.) wards off spray from the electric motor, and on the shaft between this screen and the motor is fitted a rubber washer to prevent water seeping into the shaft casing.

The whole of the instrument is covered with a Detel chlorinated rubber paint to prevent corrosion of the metal parts — especially when

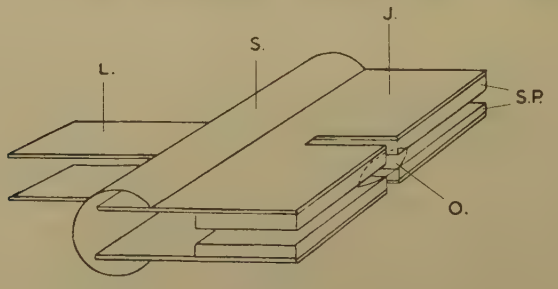

Figure 2. Diagrammatic Sketch of the Otolith Holder.

the instrument is used in a ship where only sea water is available as a coolant.

It was found during experiments that otoliths were very difficult to hold whilst being sawn, owing to the ease with which they fractured. The otolith holder (Fig. 2) is designed to prevent this. It is improvised from a bulldog paper clip whose jaws have been lengthened by soldering on brass-sheet extensions (J.). On to each jaw is stuck a sponge pad (S. P.), and it is between these pads that the otolith (O.) is firmly held under the pressure of the cylindrical spring (S.). The lower pad is shaped to support the otolith while it is being cut. A slit about an eighth of an inch wide is cut half way down the centre of each extension piece to take the saw as the holder moves on to it. A release lever (L.) ensures that the otoliths are placed in and removed from the holder speedily.

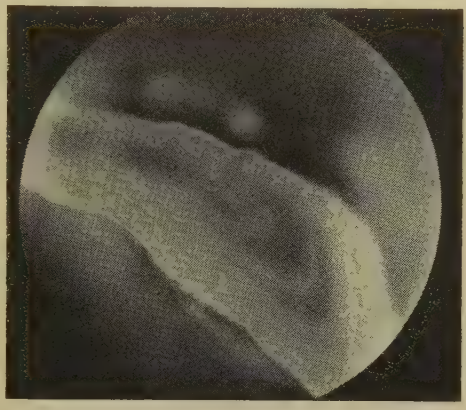

Figure 3. An Otolith sectioned by the Cutter.

A cut is performed by first placing the otolith in the holder with forceps. It need not be accurately centred as the traversing adjustor will do this. With the perspex lid closed, the motor running, and the cooling water flowing freely over the saw, the holder is slowly and carefully advanced until the saw has passed completely through the otolith. The resulting cut otolith is ready immediately for microscopic examination or for photographing. Figure 3 illustrates an otolith cut by means of this instrument.

The advantages of this otolith cutter are that its speed of sectioning exceeds that of former methods; both halves of the otolith can be kept if required; very little is wasted in dust; the saw rough-polishes as it cuts, saving an additional operation; the cooling water keeps the otoliths clean and washes away all the dust which might otherwise be spread about. The instrument itself is small, compact, and portable, and is quite inexpensive, the cost of components being only £8.

Valuable improvements to the instrument have been suggested by Mr. G. Trout, Fisheries Laboratory, Lowestoft, who has used the cutter now for over a year. Thanks are also due to those on the staff of the Government Chemist's Department who gave helpful advice.

Reference.

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The Herring Fishery and the Stock of Herring in the northern North Sea and the Skagerak during the Season 1949—50.

By

K. A. Andersson,

Lysekil.

ACCORDING to the information given in several numbers of the *Fish Trades Gazette* for the year 1949 the Scottish herring season in that year was very poor. In the number dated the 27th August it was stated that the full effect of the almost continually poor fishing is now known to constitute one of the worst seasons on record.

The herring fishery in the Skagerak carried out with the ordinary old gears, purse seine, bottom trawl, and nets, was much poorer during the 1949—1950 season than during the previous seasons. During the 1948—1949 season, floating trawls came into use for the first time for herring fishing and met with good success. In the most recent season a very great number of these trawls were used and gave good catches. Consequently the total catch for the season became somewhat greater than during the previous season. But without these floating trawls the total catch would have been much smaller than during the 1948—1949 season. During this latter season the herring occurred along the entire archipelago of the Swedish west coast, but in the 1949—1950 season the herring appeared only in the northernmost part of this archipelago. On the whole I think we can correctly say that the stock of herring in the Skagerak during the winter 1949—1950 was much weaker than during the previous seasons.

Now we may ask what are the causes of this poor stock of herring. The fishery is of course very dependent on the strength of the stock of herring, but poor catches can also be due to adverse environmental conditions. Nevertheless, I think the strength of the stock is to be regarded as the most important factor influencing the success of the fishery.

The Swedish trawl herring fishing on the Fladen Ground started in the late summer of 1945, and during the period 1945—1949 the Swedish herring investigations have dealt with the herring from the northern North Sea. In the months of August and September 1946, 1947, and 1949, cruises were made with the research vessel "Skagerak" to the Fladen Ground area for herring investigations, and samples were collected for age determinations etc. In addition, many samples from commercial catches were analysed for age, racial characters, and so on. The main part of the herring catches on the Fladen Ground consists of autumn spawners.

Further, we have sampled extensively the catches in the Skagerak during the winter season for many years. In this area also, the herring fishery is mostly based on autumn spawners. I have in previous papers endeavoured to show that the autumn spawning herring on the Fladen Ground during the autumn and in the Skagerak during the winter belong to the same population[1]).

The age analyses of all these samples seem to give a very important result.

For reasons which I have previously explained, by reading the scales with small central fields, I have omitted the innermost winter ring[2]). In this way I have, in my opinion, obtained the right age of the fish.

In Figures 1 and 2 I have given diagrams of the age distribution from the Fladen Ground and the Skagerak. Two year-classes, namely those of 1939 and 1941, are very dominant during the whole period in the both areas.

Figure 1 shows that both year-classes were already dominant in the autumn of 1945 and they continued to be so in the following five seasons. But since the year 1941 there has not emerged any new strong year-class.

After a long period of poor herring fishing in the Skagerak there was a very conspicuous increase in the fishery during January, February, and March 1944. Besides the 5, 6, and 7-year-old herring, the 4-year herring were very abundant in the catches, i.e., the 1939 year-class.

During the next season, 1944—1945, the 1941 year-class was also present in the catches as 3-year-old herring. During the following five seasons the 1939 and 1941 year-classes were also predominant in the Skagerak, and here also, there was no evidence of any abundant year brood since 1941. It may be noted that the old year-classes are still more dominant than would appear from the diagrams, as the scales of old herring, say of eight years and above, are often very difficult to read with certainty, and consequently a good proportion has been omitted.

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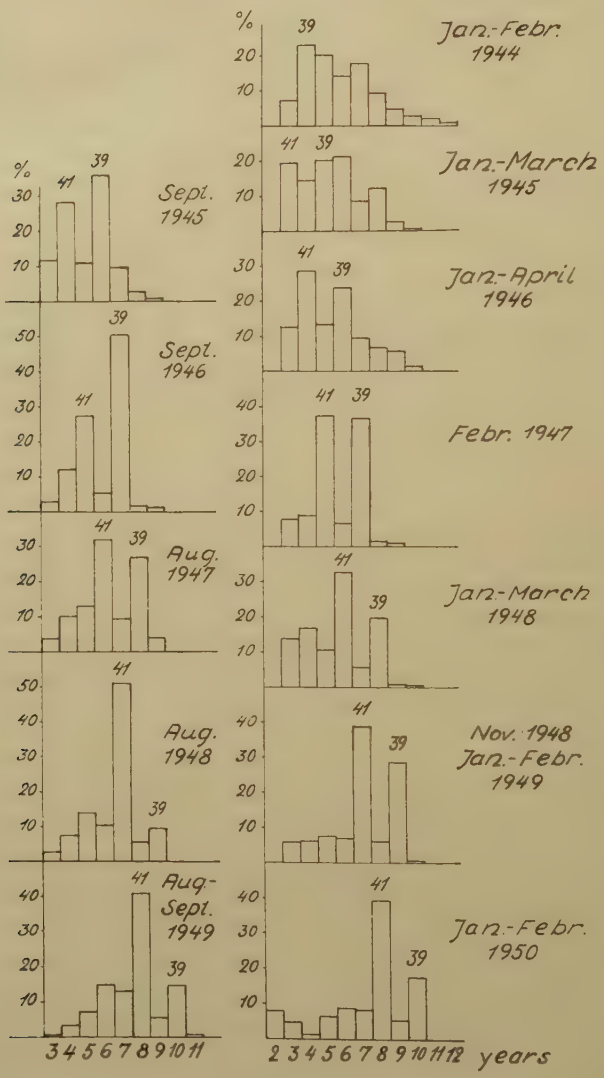
1) K. A. Andersson. "Some Remarks on the Fluctuations in the Herring Fishing on the West Coast of Sweden." Rapp. et Proc.-Verb., Vol. No. 118.

2) K. A. Andersson. "Present Herring Problems of the Swedish Herring Fishery." Rapp. et Proc.-Verb., Vol. No. 128.



Age Composition of autumn spawning Herring, 1944—1950.

Fig. 1. From the Fladen Ground.

Fig. 2. From the Skagerak.

If we compare the two diagrams from the Fladen Ground and the Skagerak we find that they are very much alike, these two year-classes dominating in the same way.

I think there is no doubt that the good herring fishery on the Fladen

Ground and in the Skagerak during the period 1944—1949 was based mainly on the abundant 1939 and 1941 year-classes, and it may be reasonable to say that these two year-classes have been of great importance for the Scottish herring fishery also.

They seem to have contributed most to the catches at an age of seven years, and as there is no younger good year-class it is quite clear that the stock of herring must decrease in proportion as the two rich year-classes grow older. The age distribution of the stock of herring last season, shown in the diagrams, seems to be very characteristic of a herring population in a state of decline. The fact that the dominant year-classes are very old and that there is no evidence of any appreciable recruitment to the stock of herring since 1941 is very likely the main cause of the poor fishery during last season in the northern North Sea and to some extent in the Skagerak also.

Unless the 1947 year-class should prove to be very strong, there is no reason to expect an increasing herring fishery during the season to come in the areas in question.

Since these lines were written the *Report on the Fisheries of Scotland* for 1949 has come into my hands. In this report evidence is given of a poor herring fishery in the North Sea during 1949, the trawl fishing excepted. Both the landings of trawl herring in Scottish ports and the number of trawlers participating in the herring fishing showed an increase, but the data of Table 11, p. 18, suggest that the increased landings during 1949 may be due to the larger number of vessels (58, 1949 as against 43, 1948). Thus the catch per vessel was smaller in 1949 than in 1948.

The total Scottish catch of herring in the North Sea in 1949, including the East Anglian fishing, amounted to 1735.6 thousand cwts. the corresponding figure for 1948 being 2787.2.

The diagram on page 17 of the Scottish report shows very clearly that the herring catches in Scotland were increasing from 1942 to 1948. This increase may be due to the two rich year-classes of 1939 and 1941.

A Review of the Papers on Molluscs Presented at the Special Scientific Meeting on Shellfish of the International Council for the Exploration of the Sea, Edinburgh, 10th October 1949.

By

P. Korringa.

Introduction.

A summary of a set of papers so different in scope and dealing with such a variety of topics as that presented at this meeting[1]) is a somewhat difficult task, which, it is thought, may be simplified to some extent by concentrating on the more debatable points of the papers read. But the fact that in the present review less attention is paid to some papers, which mainly consist of statements of fact and descriptions of the present shellfish situation in the countries concerned, than to others does not imply that these papers are of more limited scientific merit. Although classification of a heterogeneous collection of papers like the set under consideration is rather hazardous, an effort has been made to arrange them in a logical way in the present review.

Papers Dealing with Natural Beds of Molluscs.

Oyster biology and oyster culture are the subjects which predominate so conspicuously in shellfish literature that this could easily lead to the conclusion that other species of shellfish are of little importance. Though oysters predominate in yield and value in many countries, far too little scientific attention has been paid to other molluscs of commercial importance. While the number of papers on oysters and oyster culture approaches 10,000, the number dealing with mussels, clams, and other species are counted by tens, which is out of all

1) "Special Scientific Meetings 1949 — Shellfish." Rapp. et Proc.-Verb., Vol. No. 128, 1950.

proportion to their commercial importance. Therefore we should accord a special welcome to the paper by V i l e l a on the ecology of *Tapes decussatus*, a species about which very little has been published so far.

This bivalve, commercially the most important mollusc of Portugal, is found in natural beds in many places, but is most abundant on the southern coast of Portugal. There, too, one finds the parks in which young specimens taken from the natural beds are grown and fattened until they attain marketable size and quality.

Though it can be stated that this species prefers sheltered places, its present quantitative distribution along the coast of Portugal should not be considered as correlated with natural ecological factors only. Pollution and overfishing have depleted the rich beds which were once found in and near the estuaries of the rivers Sado and Tage. On the natural beds, which are in the intertidal zone, quantitative samples have been taken for investigation of the differences in density of population. The number of *Tapes* appears to be insignificant near both the high-water mark and the low-water line; the optimum density is found somewhere in between. Up to 20 or 30 specimens per dm.^{2} have been collected there. Young individuals start to make their appearance on the beds in August and September. V i l e l a claims that young individuals continue to arrive throughout winter, as samples taken in March show slightly higher figures than those taken in November.

Microscopical examination of gonads of adult specimens has clearly shown that maturation of eggs and sperm reaches a peak in June and July, and that spawning takes place in August. From September until the end of March the gonads do not contain mature products. The supposition that the pelagic life of *Tapes decussatus* lasts 2 months at least, an assumption based on the finding of very young individuals throughout autumn and early winter, is still disputable. In the first place, bivalve larvae in the temperate zone rarely require more than 4 weeks of pelagic life, as far as has been ascertained. In the second place, the smallest specimens encountered by V i l e l a measured 0·65 mm., which seems fairly large for a newly set bivalve. I would suggest searching for still smaller individuals. In young bivalves a conspicuous growth-ring marks the transition from the larval shell to the shell of the bottom stage; this might facilitate the determination of the size of the newly set individuals of *Tapes* too and thus lead to a more reliable estimate of the duration of pelagic life. If V i l e l a's samples have been preserved, the size of the larval or prodissoconch shell could be used to ascertain whether or not 0·65 mm. is the size at the setting stage, and thus whether or not the small individuals found in the course of the winter season had just left the plankton, or had already lived for some time as a sessile bivalve.

Some observations have been made on growth in *Tapes decussatus*, indicating that a size of 10—12 mm. is attained after 3 or 4 months of sedentary life, and of 20—22 mm. at the end of the first year.

Individuals from 12 mm. upwards are fished from the natural beds and transplanted to the fattening grounds. Vilela states that, as in other molluscs, the winter rings in *Tapes* do not provide a sound basis for age determination, at least not as far south as Portugal. Though it is demonstrated that the increase in length, expressed as a percentage of the initial length, is by far the greatest in young individuals, I do not doubt that the increase in weight plotted as differences from the initial weight will show a very different trend.

Another paper dealing with natural beds is that by Spärck, on the fluctuation in the stock of oysters in the Limfjord (Denmark). The natural beds in the Limfjord have existed for about a hundred years. Direct communication with the North Sea, leading to such a marked rise in salinity that the Limfjord water became inhabitable for oysters, occurred in the year 1825.

Except for the Norwegian oyster polls with their very special hydrographical conditions, in which the water temperature rises well above 20° C. in the summer months, *Ostrea edulis* approaches the northern limit of its range in the Limfjord. Prevailing water temperatures in the summer months are so low that reproduction is successful in warm summers only. This highly irregular spatfall is a drawback to the local oyster industry. The slow rate of rejuvenation of the stock renders the Limfjord beds very susceptible to overfishing. From 1914 till about 1932 the stock of oysters on the natural beds decreased. From 1925 till 1937 no fishing for oysters on the local natural beds was allowed. A spatfall of some importance was observed in the years 1932, 1939, 1942, and 1943, which brought about a gradual increase of the stock. The warm summer of 1945 gave a very good set, which led to a rapid increase and a marked rejuvenation of the stock on the natural beds in the Limfjord.

Spärck points out the noteworthy fact that the stock increased only in those parts of the Limfjord in which the remains of the natural beds were least scanty, and that no spatfall to speak of has ever been observed on the beds where millions of Dutch, French and Norwegian oysters had been relaid in certain years. Spärck's reference to my 1946 paper, in which I am supposed to say that it is impossible to revive an oyster population by transplanting mother oysters from another area, is not quite correct, for I only stated there that very large numbers of relaid mother oysters are required, unless hydrographical and biological factors are highly favourable to the reproduction of *Ostrea edulis* in the locality under consideration. An increased spatfall after relaying large numbers of Brittany oysters in Helford River (Cornwall) and in the Oosterschelde (Holland) has repeatedly been observed.

It would be most interesting, both from a biological and from a practical point of view, if it could be found out why the relaying

of many Dutch, French, and Norwegian oysters never led to a marked increase of the spatfall in the Limfjord. At least the imported Dutch and French oysters were adults, which had reproduced at least once before they were transferred to the Limfjord. Did the oysters fail to produce larvae in the Limfjord; did the larvae fail to develop; did the mature larvae fail to settle down, or did the newly settled spat fail to survive? No evidence is adduced to demonstrate which of these four factors was responsible for the newcomers' failure to reproduce in the Limfjord. A water temperature even as low as 15° C. does not stop production of eggs and sperm, in my experience. It is conceivable that Dutch and French oysters, used to a tidal amplitude of 3 to 4 metres, which influences their spawning rhythm, spawned irregularly in the Limfjord on account of its almost stagnant water. It is also possible that larvae were produced, but that they failed to develop as a result of low temperatures, lack of suitable food, presence of enemies or of toxic products in that part of the Limfjord waters in which they were hatched. Even if the larvae did develop, they may have been carried away by currents to places in which no suitable collectors enabled them to settle down. No artificial collectors were provided near the relaying beds, as far as I know, and natural cultch may have been far scarcer there than on the old natural beds, situated in other parts of the fjord. Finally, survival of the young spat may have differed greatly from that of the spat on the natural beds, due to local differences in hydrographical and biological conditions or to differences in the sensitivity of the spat. Spärck states that relaid French and Norwegian oysters are far more sensitive to prolonged cold spells than native Limfjord oysters are. I can fully confirm this for the Oosterschelde (Holland). We have no proof, however, that spat produced either in Denmark or in Holland from relaid French or Norwegian oysters differs in sensitivity to low temperatures from those spawned there from native parents. Therefore we do not yet know to what extent Spärck is right in assuming that only the native Limfjord oyster is specially adapted to Limfjord conditions. Observations on reproduction and survival of oysters relaid in the Limfjord may be of the greatest interest.

Spärck states that his observations provide conclusive evidence that even a seriously reduced stock of oysters may recover in the course of some 10 years if no fishing, pests, or diseases counteract this development. We should remember, however, that no strong tidal currents disperse the oyster larvae in the Limfjord, nor carry them away to districts where they cannot settle and survive. If, therefore, temperature and food conditions favour larval development in a given year, a fair percentage of the larvae produced may settle down on or near the natural beds.

A gradual recovery in a period of some 10 years of no fishing is hardly attractive to the oyster industry, which needs a fair production of spat at least every other year. The irregular reproduction of *Ostrea*

edulis in the Limfjord, on the northern fringe of its range, makes it difficult to create and maintain a self-supporting oyster industry, as special measures to promote the spatfall — fairly expensive nowadays — must be remunerative.

Efforts to Create a Self-Supporting Oyster Industry.

In their paper "La situation de l'ostréiculture dans le Bassin de Chasse d'Ostende de 1939 à 1948", Halewyck and Leloup describe observations on growth, fattening, and reproduction of oysters in the shallow 84 HA Bassin de Chasse at Ostend, Belgium. Before 1939 the experiments gave such good results that commercial exploitation of the basin seemed possible. Both a great number of young oysters, settled there in 1939, and nearly 2,000,000 relaid French oysters populated the basin when Belgium was forced into war in May 1940. Due to war conditions inspection was impossible between June 1940 and January 1941. In that month the Germans ordered the basin to be emptied during severe frost, which killed off the oysters to practically negligible numbers. Next, the Germans had a dike constructed in order to raise the water level of the basin. Regular renewal of the water became impossible after the construction of the dike. After the liberation of the country, in 1944, observations and experiments on oysters in the Bassin de Chasse were resumed. The few surviving oysters, and also some fishes, appeared to be very thin and lean in the winters 1944—1945 and 1945—1946. It is suggested that the higher salinity, brought about by the construction of the dike, was responsible for poor fattening conditions.

In the warm summer of 1947 Brittany oysters, relaid in the basin in April, reproduced abundantly, but failed to grow and fatten. In striking contrast to this, relaid Portuguese oysters (*Gryphaea angulata*) grew and fattened remarkably well in the very same basin. Intra-specific competition for food is advanced as an explanation of the differences observed, the authors arguing that the Portuguese oyster filters far more water per hour than *Ostrea edulis* does. The good results obtained with *Gryphaea angulata* led to the relaying of 150,000 Portuguese oysters in the year 1948. They developed well enough, but it was difficult to market them in Belgium, where the buyers are used to the superior flavour of *Ostrea edulis*. Notwithstanding the larger number of Portuguese oysters relaid in that year, the flat oysters present (*Ostrea edulis*), though showing poor growth only, fattened satisfactorily, which is difficult to explain.

The authors conclude that under present conditions growth and fattening of Portuguese oysters seems promising in the Bassin de Chasse, but marketing them is so difficult in Belgium that commercial exploitation is not attractive. Growth and fattening of *Ostrea edulis* is not satisfactory now, which is regretted, as an excellent market

exist for this species in Belgium. Reproduction of *Ostrea edulis* is irregular in the basin, mainly because such a shallow body of water responds very rapidly to changes in meteorological conditions, which renders larval development and setting too hazardous for commercial exploitation.

The authors suggest that growth and fattening of *Ostrea edulis* may be greatly improved by restoring the pre-war hydrographical conditions, involving a lower salinity of the water. I do not believe that there is as yet sufficient evidence to support that view. *Ostrea edulis* may fatten very satisfactorily in waters from 25 to 36 $^0/_{00}$ salinity, and at different temperatures. Quality and quantity of suitable food is a factor of far greater importance than salinity and temperature only. The problem of intra-specific competition for food is still far from settled, since we do not yet know on which sizes of food-particles the different species specialize. We must confess, however, that we are not yet in a position to recommend a procedure for measuring the quality and quantity of food for *Ostrea edulis* and *Gryphaea angulata*. Examination of the usual samples of net-caught plankton is most probably of limited use only in studying this problem.

A paper of very modest dimensions is that by Millar, who describes the efforts to revive the oyster industry of Scotland, formerly so important. By relaying batches of oysters (*Ostrea edulis*) and observing their growth and survival, efforts are being made to find out what places are suitable for oysters.

Next, an attempt has been made to produce oysters by tank breeding. To this end a 240 m^3. outdoor tank, filled with sea water, was used in the year 1948. To avoid too low temperatures the sea water was covered with a layer of fresh water, which is a common practice in the Norwegian oyster polls. We should like to know how the wind has been prevented from mixing the fresh upper layers with the underlying sea water in the tank. It is amazing to learn that the tank, filled in May, and stocked with 400 adult oysters, produced months later two crops of spat, one in August, and a heavy one in September. Apparently the very same seawater, stagnant as it was, remained in perfect condition all these months. This implies that not only must enough food organisms for oyster larvae have been present, but also that toxic conditions, e. g., due to intense assimilation, did not arise. From my own experience I presumed that very pure water was used to fill the tank, and that neither inorganic nor organic manure was added, and this presumption was confirmed by Mr. Millar during the meeting. It will be interesting to study his data on hydrographical and biological conditions in the tank in the course of the experiment, which, it is mentioned, were collected.

General Descriptions of the Present State of National Shellfish Industries.

A general survey of the shellfish industry in Holland is given by Havinga. *Ostrea edulis,* ranking first in value, is produced by oyster culture in the Oosterschelde (Province of Zealand). Up to 1920 a fishery on natural beds existed in the Waddensea in the northern part of the country.

The Dutch oyster culture met with the greatest difficulties in the years following 1930, difficulties caused by the imported oyster pest *Crepidula fornicata,* and by an outbreak of shell disease, both of which are dealt with in greater detail in papers presented by me at this meeting. Both the relaying of French oysters and the results of biological research led to a gradual rehabilitation of the Dutch oyster industry.

Mussel farming is a very important industry in Holland. The mussels are fished on natural beds in the Waddensea, and either used directly (mainly on duck farms) or relaid on the mussel beds of the Zealand streams. Here they grow and fatten until they attain the fine quality much in demand in foreign markets, to which the overwhelming majority of the Dutch mussels is exported.

Little is known of the mussel's biology. Compared with *Ostrea edulis,* too little time has been devoted to studying the biology and cultivation of the mussel, a species of great commercial importance in western Europe. We know very little indeed about the factors governing the production of young mussels, about the factors determining growth and fattening, and about mussel diseases. Between 1898 and 1918 the Zealand mussel beds were depleted several times by a mysterious disease. A local but serious mortality, observed in September 1949, showing symptoms resembling those observed when the mussel disease ravaged the beds in former years, appeared to be caused by the parasitic copepod *Mytilicola intestinalis.* This problem is now the subject of a detailed investigation.

Other species of edible molluscs, fished on natural beds (cockles, clams, whelks, and periwinkles), are of limited economical importance in Holland. The whelk suffers from overfishing; the periwinkle output declined suddenly when the eelgrass disappeared completely in 1932.

Lambert's paper ("Les huîtres des côtes Françaises") deals with the present conditions and methods used in the French oyster industry. Natural beds of *Ostrea edulis* (l'huître plate) are rare nowadays along the French coast, and are so poorly stocked that they are no longer of commercial importance. Efforts to revive the natural beds have failed so far. The remains of the natural beds are found north of the Loire river. On the other hand a comparative newcomer to France, the Portuguese oyster (*Gryphaea angulata*) has managed to establish,

since the year 1867, many productive natural beds on the Atlantic coast of France south of the River Loire. The important fishery for Portuguese oysters on the natural beds is regulated. The oysters fished there are usually relaid on oyster beds and in ponds (claires) for further growth and fattening. The French output of Portuguese oysters outnumbers that of flat oysters many times.

Virtually the entire output of flat oysters (*Ostrea edulis*) is produced by oyster culture. Though some spat is collected in many places, with a variety of collectors, there are two main centres of spat-production, viz., the Morbihan district of Brittany, and the Basin of Arcachon, south of Bordeaux. In both centres millions of tile collectors are used in the production of spat. In special parts of the latter district Portuguese spat is produced as well with the aid of tile collectors.

Preparing and placing tile collectors, as well as taking the spat from the tiles, involves a great deal of manual labour, and so does the rearing of the young oysters in the first few years of their existence. Until very recently practically all the French oysters were grown in the intertidal zone, and cleaned and collected by hand at low tide. Now trials have been started of growing oysters in deeper water and harvesting them with dredges, methods modelled on the Dutch oyster cultural systems.

The French oyster farmer knows that oysters do not always fatten well where growth is more or less satisfactory. He knows by experience that fattening is excellent in certain districts. Therefore the "affinage", the fattening of market oysters, is practiced especially in the districts of the River Seudre (Marennes), and of the rivers Belon and Pénerf in Brittany. In the Seudre district shallow ponds (claires) are used to this end. One hopes that the oysters in the claires will not only grow and fatten, but will also develop green-coloured gills, which is attended by the acquisition of a very special and much sought-after flavour. The development of the green colour and special flavour, usually ascribed to the diatom *Navicula ostrearia,* is difficult to control and capricious in its occurrence.

A further centre for promoting rapid growth and fattening is the Etang de Thau on the Mediterranean coast of France, where the oysters hang freely in the water, glued to poles of hard colonial wood, and are thus free from silting and from many predators.

In an effort to cover the whole of the ground L a m b e r t gives a great number of details on spat-collection, growing and fattening, and cleaning and marketing of oysters; so many details, in fact, that there is great danger of a reader unfamiliar with the French oyster industry not seeing the wood for trees. L a m b e r t deals only with the present culture methods and the overall situation, and not with the current biological, cultural, and commercial problems of the French oyster industry.

A very interesting paper is that by Cole on the British oyster industry and its problems. The British oyster industry, once of great importance, is now in a very difficult position indeed, due to overfishing, diseases, pests, and pollution. The principal problems of the present times are not only discussed very frankly and clearly by Cole, but many valuable suggestions are given for overcoming the difficulties, which demonstrate both a clear insight into the current problems and a great enthusiasm for tackling them. Cole's paper is so stimulating that one is inclined to say of the British oyster industry, "The hour before the dawn is the darkest".

Broadly speaking, Cole aims in the first place at reversing the serious decline by expanding production; in the second place, at cheapening production to such an extent that the oyster will again become a food for general consumption. Though I believe in the possibility of restoring and expanding the British oyster industry when serious large-scale efforts are made, I do not believe it possible to produce oysters very cheaply. Oysters were very cheap indeed in the days of free fishing on the rich natural beds of Britain, when catching and transport were the only expenses involved. A general revival of natural beds seems hardly possible; only through oyster culture may one hope to raise the production of oysters considerably. Modern oyster culture, entailing much labour and considerable expense, cannot easily lead to the production of very cheap oysters. If one wants to be sure of a regular output of good quality oysters on a commercial scale, one should not shrink from using methods similar to those used by the modern fruitgrower. Especially on beds like the British, overrun by a variety of parasites and pests, the most modern methods of mechanical and chemical control will be necessary to attain a considerable increase in the British oyster production, and to maintain the beds in perfect condition. This can lead to a less expensive, but hardly to a really cheap oyster.

Dealing with spatfall failures, Cole concludes that many of the British oyster beds are so seriously understocked that a spatfall of commercial magnitude is only to be expected under exceptionally favourable conditions. Only in Helford River (Cornwall) is a sufficient stock present to give regular spatfalls, mainly because many Brittany oysters are relaid on those beds. Cole advocates planting a fair quantity of oysters among the cultch to provide a focus for gregarious settlement. Though Dutch oystermen will agree with Cole that this is a sound project, we should not forget that the majority of the artificial collectors used in France and Holland is placed rather far from the mother oysters, and collect an optimum set there.

Cole points out that artificial collectors require very much labour, and that this means expensive hired labour in England. That is perfectly true. Only where setting is fairly profuse can oystermen afford to use artificial collectors. This is usually not the case in overfished and understocked districts. The fouling of artificial collectors,

mentioned by Cole, brought about by a variety of sedentary organisms, can be counteracted by modern methods. Dr. Engle of the Annapolis Fish and Wildlife Laboratory (Maryland, U. S. A.), informed me recently, by letter, that spraying D. D. T. on the collectors, before scattering them is of great help in the fight against barnacles and bryozoa. Fouling organisms threatening to smother the young spat can be killed by methods similar to those developed in Holland to eliminate *Crepidula*. Here again, one can only afford the expense where a fair or profuse set can be expected regularly.

Severe winters have done a lot of damage in Britain in recent years. Relaid Brittany oysters are far more sensitive to prolonged cold spells than native oysters. Cole assumes that a reduced salinity after a cold spell is an important factor in winter mortality. This may be true, but the Dutch oyster district knows serious winter mortality, especially among relaid Brittany oysters, without the occurrence of a reduced salinity. Our impression is that strong winds, stirring up the sediments, can also do a lot of damage among oysters weakened by prolonged cold spells.

Cole suggests starting a complete research designed to elucidate the basic principles underlying the use of winter pits, formerly used on a large scale in the east-coast oyster districts. I can add that large covered basins with circulating water, which can be kept at a constant temperature in any kind of weather, like those built recently by several Dutch oyster companies, can be used to protect even the sensitive Brittany oysters in a severe winter. Working expenses of such basins are remarkably low and an amazing number of oysters can be stored in such basins in the colder season, when oxygen requirements are low.

Dealing with the serious oyster pest *Crepidula*, Cole states that dredging is an efficient method of cleaning the beds. Unfortunately the British oystermen have not got powerful boats equipped with heavy, power-hauled dredges, like their Dutch colleagues. We can support from our own experience Cole's conclusion that it is possible to maintain the oyster grounds reasonably free from *Crepidula* by thorough dredging.

The drill *Urosalpinx* usually escapes through the meshes of the dredge. Hydraulic dredges, like those used in Long Island Sound, which collect considerable quantities of smaller objects too, would be more effective in fighting *Urosalpinx*. Unfortunately such dredges are rather expensive.

Next, Cole mentions the fear of the oystermen that the devastating and mysterious oyster disease of 1920—21 may reappear on British beds. Shell disease does not occur on the British beds, but I believe that the fungus which causes this disease may be present in Britain and many other countries. It only attacks oysters on a large scale under very special ecological conditions. Dutch oysters carrying the disease have been relaid several times in the past. Moreover British oystermen recently relaid several lots of Brittany oysters fairly heavily

infected by shell disease. Therefore it seems unnecessary to create special barriers against introduction of this disease.

Another important problem of the British oyster industry is industrial and sewage pollution. Cole points out the danger of sterilizing sewage and discharging a toxic effluent in British coastal waters. He also deals with the ineradicable prejudice of the British public against the use of chlorine in purification plants, and the unreliability of ozone methods. I wonder whether ultraviolet light might be of use in sterilizing sea water. Efficient storage pits are considered very useful for eliminating slight pollution, but the British oyster industry does not yet possess such pits.

Restocking the British beds is a difficult problem. Both French and Norwegian oysters are far more sensitive to low temperatures than British natives and Dutch oysters are. It is not known whether or not spat from French or Norwegian parents in British waters possesses the frost-resistant qualities of the British oysters. For the same reason, doubt remains whether imported oysters or their offspring will ever attain the famous flavour of the genuine British "natives". In this connexion it may be of interest to mention that Brittany oysters can be distinguished by the taste from native Dutch oysters fattened on the very same bed for several months; also that the famous "gravette" of the Basin of Arcachon did not return after the general revival of the oyster industry there.

Cole concludes with a suggestion worth serious consideration, namely that genetical research should be initiated as soon as possible with the aim of selecting and fixing quick-growing, frost-resistant strains of oysters of superior marketable quality. This would be a benefit to the entire European oyster industry. Too little is known of the qualities which are hereditary in the oyster. Research and application seem possible now that tank-breeding experiments and restocking programmes are in full swing. A quick-growing and resistant oyster grown on a large scale can lead to cheaper production, which is one of Cole's ideals.

Papers Dealing with Special Aspects of Oyster Biology and Oyster Culture.

An intriguing paper is that by Knight Jones on aspects of the setting behaviour of larvae of *Ostrea edulis*. He first discusses the influence of the angle of surface of the collectors on the intensity of setting. Observations and experiments on setting on upper and lower horizontal surfaces are conflicting. Knight Jones experimented in the River Crouch (Essex) and found a far better setting on lower horizontal surfaces. He is inclined to ascribe the conflicting evidence from the Oosterschelde (Holland) to turbulence caused by the adjacent experimental slides. However, the topmost slide of the set of three

used there bore more spat on the upper horizontal surface too. So far unpublished investigations, carried out in the Oosterschelde since 1940, show that silting is a very important factor in setting. In many places upper horizontal surfaces are liable to quick silting. Where even a slight silting is evident, upper horizontal surfaces lag far behind lower surfaces in setting. In almost any place survival of spat is far better on lower horizontal surfaces. Where silting is considerable upper horizontal surfaces of collectors are not interesting at all to oystermen, e.g., in the Brittany oyster district.

Next, Knight Jones adduces evidence that greater numbers of oyster larvae settle down in the vicinity of already settled spat or of larger oysters. Peculiarly enough, this gregarious tendency was most marked when the spatfall was light. The hypothesis is advanced that crawling larvae are induced to proceed with setting, if there is already spat in the neighbourhood, by some secretion from the spat (or from older oysters) borne by water currents or diffusion.

The Dutch oystermen claim that a more profuse spatfall can be expected on beds where oysters have been scattered among the shells used as cultch than on beds bearing shells only. This would support Knight Jones's findings. On the other hand tile collectors usually bear the greatest number of spat on places miles and miles away from the oyster beds. I have also repeatedly observed an excellent setting on beds carrying shells only. The hypothesis of a water-soluble substance as agent in the gregarious habits of the oyster is interesting, but debatable. It is hard to see how water-soluble substances induce important differences in setting intensity in stations less than 100 metres apart in rivers with strong tidal currents. I cannot give a better explanation of the unmistakable facts. Micro-hydrographical conditions, especially slight differences in currents and shelter, are important during the setting of oyster larvae. Living oysters themselves influence the micro-hydrographical conditions on oyster beds. Further, silting and fouling may be different where living oysters occur. In the Conway tanks, however, where the first observations on this gregarious tendency were made, currents are practically absent. The well known American oyster biologist Th. C. Nelson once advanced the somewhat fantastic hypothesis that mature larvae may be concentrated on beds where adult oysters live, because they are ingested in great numbers by the older oysters, crawl out of their faeces in due time, and settle in the vicinity without much delay. We certainly hope that more light will be thrown in due time on the important problem of gregarious tendency in the setting of oyster larvae. Most probably the entire oyster industry will profit on a large scale from a more profound knowledge on the setting behaviour of larvae.

Investigations on shell disease in *Ostrea edulis* were discussed in a paper by me. Shell disease, characterized by more or less serious

malformations of the shells and heavy mortality among young oysters, threatened the Dutch oyster industry with extinction in the years following 1930. Extensive investigations, mainly carried out in the field, revealed bit by bit, in the course of several years, the secrets and uniformities of this once mysterious disease. It appeared to be caused by a fungus, thriving abundantly in old green cockle-shells, used in tremendous quantities as cultch in the years 1920—1930, and fouled since. During hot spells spores of the fungus are distributed by water currents and are able to attack thin parts of the oyster's shell. A better understanding of the character and epidemiology of this disease enabled infection to be avoided, and led later to the wholesale cleaning up of the beds bearing the old, useless *Cardium*-shells. Next a method was found to kill the fungus, living in the oyster's shell-shoots and thus completely to cure oysters recently attacked by this disease. Fortunately the Dutch oystermen adopted this new method immediately. Disinfection of spat and young oysters is now a common practice in the Dutch oyster districts. After the warm summer of 1947 more than 15,000,000 one-year-old oysters were saved from certain death by this new method. From this it may be concluded that biological research may yield results of great practical importance of which the fruits can be gathered at short notice.

My second paper presented at the Shellfish Meeting is entitled "*Crepidula fornicata* as an oyster pest". A short description of *Crepidula's* arrival and spreading in the Dutch oyster centre, the Oosterschelde, is given. *Crepidula* found a very congenial home in the Oosterschelde, as many oyster beds were amply provided with cockle-shells, scattered there by the oystermen as cultch in the period 1920—1930. The reasons are discussed why *Crepidula* should be considered an oyster pest. Evidence is adduced that it takes the place meant for the young oysters and thereby seriously handicaps spat production. Besides this, recently set oyster spat is easily crowded out by a profuse set of *Crepidula*. Competition for food is of minor, if any, importance.

Crepidula-infested oyster beds can be cleaned and maintained in good condition by thorough dredging. In the war years *Crepidula* was used in the manufacture of meat lozenge and similar products.

Young mussels can be used to smother *Crepidula* in badly infested areas not in use by the oyster industry. It appeared that thin and friable shells, like mussel-shells (*Mytilus edulis*), can be used to collect oyster spat, even where *Crepidula* is prevalent.

A very recent development is chemical control of *Crepidula*. Shells and other collectors on which both oyster spat and limpets settled can be freed of *Crepidula* by keeping it about two hours in a very dilute solution of poison (corrosive sublimate, 1 : 15,000, or copper sulphate, 1 : 5,000, may be used). The young oysters keep tightly closed in this solution, but *Crepidula* lifts its shell and proceeds to pass the

poisonous solution through the gills, as if it had not observed the presence of the dangerous poison. It is expected that this cheap method will be applied on a large scale by the Dutch oystermen.

Oyster culture in Norway. In the second part of his paper Dannevig discusses the problems of the Norwegian oyster industry. Spat collection is carried out in the Norwegian oyster polls, stagnant bodies of water which attain high temperatures in summer. Norway lacks beds on which oysters can be scattered to grow and fatten. Marketable oysters are grown in suspended baskets of galvanized-iron netting, which is a rather expensive method.

Mortality is high where considerable variations in salinity occur. Dannevig is inclined to ascribe winter mortality in the first place to a reduced salinity. Oyster spat produced in polls on Norway's west coast is liable to serious mortality when grown in south-eastern Norway. Dannevig ascribes this to a lower salinity on the east coast. It may be difficult, however, to separate the effect of salinity from that of temperature. The fact that both French oysters and oysters produced in the polls of Norway's west coast are sensitive to prolonged cold spells suggests that high water temperatures during setting and early youth may entail vulnerability in cold winters. Our finding is of interest that Brittany oysters which have experienced a rather mild winter in Holland have been able to stand a fairly severe winter next year. The entire problem of the factors involved in winter mortality needs further research.

Dannevig mentions attempts to produce oyster spat in the ponds of the Hatchery Station at Flødevigen (near Arendal, Norway). Though it has been possible to create a rich plankton by adding inorganic manure, it has not yet been possible to stabilize the output of oyster spat.

For experimental purposes a method has been developed by Dannevig for producing oyster larvae in winter and early spring in the laboratory.

Tank breeding. A third paper by myself deals with difficulties encountered in tank breeding of oysters. Tank breeding is considered important not only for those countries where serious overfishing makes commercial spat production on the natural beds practically impossible, but also for investigating the problem of heredity and selection in the oyster, which promises results of great practical importance.

Though considerable experience has been gained in the tanks of the Conway Fisheries Experimental Station, where Cole developed a method of increasing the number of suitable food organisms, tank

breeding of oysters is not yet a foolproof procedure. My own experience makes it highly probable that food, temperature, salinity, pH, and oxygen are not the only factors involved in tank breeding of oysters. Evidence is adduced to support my hypothesis that many failures in tank breeding may be ascribed to an accumulation of toxic excretions produced by small nanoplanktonic flagellates.

Conditions identical to those in a "poisoned" tank have been detected in a fairly stagnant body of water in open communication with the Oosterschelde.

Sanitary Control.

Three papers dealing with sanitary control of shellfish were read. Lambert describes the French methods and problems in great detail. The waters in many of the French shellfish centres are reasonably free from pollution. Accordingly methods could be developed and applied to furnishing the markets with shellfish that met the requirements of the hygienist. A strict control is exercised to prevent marketing of shellfish from polluted beds and basins. As infringements may entail rigorous punitive measures, the collaboration of the shellfish industry is ensured. A potential danger which remains is the collection of wild shellfish by seaside visitors not aware or not convinced of pollution.

Sherwood discusses sanitary control of shellfish in England. Pollution is a very serious problem in many of England's coastal districts. Though it has never been seriously difficult to distinguish between the extremes of safe and dangerous sources of shellfish, the category "doubtful" offers considerable problems, and leaves much scope for individual opinion. The need for methods and standards of bacteriological control, recognized both nationally and internationally, is emphasized by Sherwood. Unfortunately international contact was not resumed after the 1932 conference at Middelburg. Unlike France and Holland, England has as yet no generally accepted bacteriological standard for shellfish. Local public health authorities have to depend upon bacteriological findings, as they themselves usually cannot undertake topographical investigations. In certain places, only shellfish which has been purified at approved stations is admitted. Under present conditions shellfish from areas closed to the markets of one municipality may be accepted in those of another. Adoption of a recognized system of classification of sources and generally accepted bacteriological techniques and standards is recommended.

Grijns discusses the bacteriological control of shellfish in Zealand (Holland). As in France, the majority of beds and basins is practically

free from pollution. Shellfish from polluted beds may only be marketed after a fairly long sojourn on a clean bed. A thorough control service on the water and around the basins sees that none of the regulations is infringed. The Dutch methods for bacteriological examination of samples of shellfish and water are described in detail. The effectiveness of the system is clearly demonstrated by the fact that within a period of 45 years no case of typhoid fever caused by the consumption of Zealand oysters or mussels has been recorded.

Though G r i j n s admits that the establishment of purification plants for shellfish is important in many coastal districts of England, where serious pollution prevails, he stresses that it is unfair to enforce a law that all shellfish should pass through such plants. Though G r i j n s admits the safeness of the purification treatment, he has aesthetic objection against it. I believe everybody will agree with his opinion that it is more attractive to eat shellfish from clean sea water than from a chlorinated mixture of sea water and sewage, however safe that may be.

Editorial Note.

A new scientific periodical, the "*Australian Journal of Marine and Freshwater Research*", has been established by the Commonwealth Scientific and Industrial Research Organization as a medium for the publication of research papers on the results of original investigations on sea, estuarine, and freshwater fisheries and cognate subjects. Dr. N. S. Noble, of the Organization's staff, has been appointed as Editor of the new Journal.

The Journal will not be issued at set periods, but as the accumulation of suitable material dictates. It is possible, however, that two issues will be made each year. The subscription rate is 7/6 per issue. The first number is dated April 1950, and enquiries and orders for the new Journal should be addressed to the Secretary, C. S. I. R. O., 314 Albert Street, East Melbourne, C. 2.

Letter to the Editor.

Dear Sir,

Because of the weight conferred upon it by publication in the *Journal*, I should be grateful for opportunity to deny Kesteven's assertion (1950, *J. Cons.* XVI, 2:228) that while using certain data, I have otherwise sought to discredit the program of the International Fisheries Commission. A statement of difference concerning interpretation of biological data accepted as probably reliable, cannot be described as an effort to discredit the program of investigation producing the data. My expressed admiration for the magnificent research accomplishments of the Commission is in no way diminished by my general conclusion that the desirability of applying current theories of management to marine fisheries remains undemonstrated.

W. F. Thompson himself (1950, *Publ. Fish. Res. Inst. Univ. Washington*), in an elegant but astonishing rejoinder to my analysis of his previous results, indicates as much doubt of the Commission's research program as have I of its management program. Consider, for example, the implications of his basic premise, that annual catch on the western grounds in 1927—1930 was over half the total stock annually available (pp. 56, 49, 33); when contrasted with the maintained low rate of return from the Commission's carefully planned tagging experiments, and the supporting evidence that a majority of the catch had been vulnerable to fishing for several or many years before capture. Yet surely it would not be thought proper for Kesteven to describe Thompson as basing his argument on data from management, whilst otherwise seeking to discredit the Commission's program?

In addition to other misapprehensions, which it seems unnecessary to discuss in this communication, Kesteven's essay suggests a certain lack of appreciation of quantitative distinctions. For example, if the effect of natural changes on the biomass time-derivative should sufficiently outweigh that of fishing, the "general theory of fishing" in which Kesteven affirms faith on page 234 might remain as logical a construct as when formulated in his previous papers, but would hardly afford valid or useful means of describing the fishery situation.

Despite the above criticism, Kesteven's essay seems to me to display commendable adaptation to the change in trend of fisheries thought. It is with interest that I await the *Journal's* review of Thompson's paper.

Very truly yours,

Martin D. Burkenroad.

30. June 1950.

Institute of Marine Science,
The University of Texas,
Port Aransas, Texas.
and
Ecos, Bogue Sound Road,
Newport, North Carolina.

Reviews.

Jens Eggvin. "The Movements of a Cold Water Front: temperature variations along the Norwegian coast based on surface Thermograph records." Fiskeridirek. Skr., Ser. Havunders. (Rpt. Norwegian Fish. and Mar. Invest.) Vol. **6**, No. 5, 151 pp., 50 figs., 2 pl. Bergen, 1940.

Continuous temperature records from thermographs registering at 4 metres' depth in the condenser intake pipes of regular steamers plying along the entire coast of Norway form the basis of this paper. For amplification or argument these thermographs are supplemented by regular temperature and salinity observations taken at a fixed "station" at the entrance to Sognefjord, and by serial observations from surface to bottom in five short sections normal to the coastline.

By table, diagram, and text, there is given a mass of detailed information on the hydrography, principally the temperature, of the uppermost waters of the Norwegian coastal region, and on their seasonal and geographical variations on different sections of the coast. Thus, the waters along the Skagerak section of the Norwegian coast, due to relatively fresh Baltic water influence, show the greatest seasonal temperature variations of the entire coastline, while the northernmost coastal waters around Finmark, from being constantly under the influence of oceanic water of Atlantic origin, show the least variation.

By reference to the period between April 1935 and June 1936, annual fluctuation in seasonal temperature of the upper waters is associated with meteorological factors, principally with winds and to a less extent, cloud cover and air temperature.

Connexion is also established in the early months of 1937 between the distribution of air pressure, the resulting winds, excess Baltic water effluent — the progress of which along the Skagerak and west Norwegian coasts is closely followed, geographically and in time, by continuous thermographic registration — and the Norwegian spring herring fishery of the south-west coast.

The paper, in its various parts, is somewhat difficult to follow, possibly owing in some measure to the author's writing in a foreign language, but it is clear that continuous thermographic temperature recording in a region so influenced as is the Norwegian coastal region by radically different water masses, is a most valuable aid, both scientifically and commercially, in prognosticating hydrographical conditions, especially those which may later be not merely unfavourable, but disastrous, to the Norwegian fishing industry.

J. B. Tait.

H. Stommel. "Horizontal diffusion due to oceanic turbulence." Journ. Mar. Res., Vol. **8**, No. 3, pp. 199—225, figs. 1—3. New Haven, Conn., 1949.

G. K. Batchelor. "The application of the similarity theory of turbulence to atmospheric diffussion." Quart. Journ. Roy. Meteor. Soc., Vol. **76**, No. 328, pp. 133—146. London, 1950.

For many years oceanographers have calculated coefficients of eddy-diffusion and eddy-viscosity from observations relating to various kinds of motion in the sea. The processes of calculation have depended on certain hypotheses, and these hypotheses have usually not been satisfied. In consequence, the magnitudes obtained for the coefficients can only be regarded as special kinds of statistical indices relating to each particular set of circumstances taken as a whole. But the magnitudes are of value, even though their precise interpretation may be very difficult.

A coefficient of eddy-diffusion of salinity, defined in terms of the time-rate of passage of salt across an area in the sea, will depend not only on the state of turbulence of the motion of the sea, but also on the distribution of the salinity itself.

The most obvious feature of the results is that the magnitudes of the coefficients of eddy-diffusion and of eddy-viscosity increase with the size of the region of the sea considered. Associated with this scale-effect is the fact that coefficients depending on horizontal turbulence are of the order of 10^4 times those depending on vertical turbulence.

Many years ago L. F. Richardson[1]) studied diffusion in the atmosphere, where the conditions are somewhat analogous to those in the ocean. He introduced the conception of eddies within eddies, the smaller drawing their energy from the larger. In 1926 he examined the magnitudes which had been evaluated for the coefficients of diffusion K, no matter how defined, in relation to the linear size L of the region over which the observations were made. For five groups of observations ranging in scale from L = 15 m. to 50 km., he found the rough relationship

$$K \propto L^{4/3} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Richardson then abandoned the use of coefficients of eddy-diffusion defined in connexion with a Fickian differential equation, and introduced a quantity $q(l)$ depending on the distance apart l of pairs of identifiable particles. For a set of such particles $q(l)$ is the frequency distribution of pairs in relation to their distance apart. He introduced a function $F(l)$ in terms of which the change of $q(l)$ could be assumed to depend, so that

$$\frac{\partial q}{\partial t} = \frac{\partial}{\partial l}\left\{ F(l) \frac{\partial q}{\partial l} \right\} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Part I of Stommel's paper is an account of an analysis of observations of bits of matter floating in the sea, the analysis being carried out in Richardson's manner. The observations were made at Blairmore (Scotland), Woods Hole, and Bermuda, aerial photography being used in the second and third instances. The values of l ranged from 26·7 cm. to 116 m., and for a series of observations it was found that

$$F(l) \propto l^{4/3} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

though the factors of proportionality were not the same in each series.

[1]) References to all papers quoted are given in each of the papers reviewed.

In 1941 A. N. Kolmogoroff introduced a set of hypotheses regarding the structure of turbulent motion; and the same ideas, in different forms, were subsequently put forward by L. Onsager in 1945, C. F. von Weizsäcker and W. Heisenberg in 1948. These hypotheses are built round the idea of eddies within eddies, and the different scales of motion which occur in the sea form a good example of this idea.

Part II of Stommel's paper is a review of Weizsäcker's theory of the spectrum of turbulence for large Reynolds numbers, and a discussion of the possible application of this theory to the ocean. The chief features of the theory are presented in a two-dimensional form, so as to be applicable to motions which are practically horizontal. It is assumed that the energy of any eddy comes from a larger eddy and that it is dissipated into smaller eddies until the smallest eddies are reached; these are laminar and dissipate their energy into heat through molecular viscosity. For any linear scale L_n, it is possible to define a "relative mean motion" and a "turbulent motion" so that this turbulent motion contributes to the relative mean motion of the next smaller scale L_{n+1}. For each scale the time-rate of transference of energy from the relative mean motion to the turbulent motion is expressed in the form

$$\varrho\, N\, \Phi \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

per volume, where ϱ is the density of the water, N the "coefficient of eddy-viscosity" and Φ the same function of the relative mean motion as φ is of the total motion when the viscous dissipation of energy is given by

$$\varrho\, \nu\, \varphi$$

per volume, ν being the kinematical coefficient of molecular viscosity. Such a procedure defines a coefficient of eddy-viscosity N_n for each scale L_n. So long as no energy is supplied to the motions from outside the ocean, and the scales are too large for appreciable viscous dissipation of the energy of the relative mean motions, the time-rate at which energy is transfered from the relative mean motion at any scale to the turbulent motion at that scale is assumed to be the same for the different scales. From this, with the aid of certain hypotheses of similarity, it is deduced that

$$N_n \propto L_n^{4/3} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

Batchelor's paper is an outline of Kolmogoroff's theory and a consideration of the possibility of its application to atmospheric and oceanic turbulence. Special attention is given to the scales of motion for which the hypotheses are applicable. He shows that they cannot be applied to diffusion from a fixed source, such as when radioactive effluent is poured into the sea. He then considers diffusion from a moving centre such as is studied in Part I of Stommel's paper, and he obtains a number of formulæ more complicated than (3).

J. Proudman.

J. J. Tesch. "Heteropoda." Dana-Report No. 34, 53 pp., 5 pl., 44 text-figs. Copenhagen and London, 1949.

The Carlsberg Foundation has been particularly fortunate in securing the services of Dr. Tesch to work out the rich heteropod collections brought

back by the "Dana" expeditions. He has a lifetime of experience in the study of this small but aberrant group of molluscs.

In the introduction the author presents a brief review of the history of the group and gives a useful list of earlier works on anatomy and histology. In a previous report T e s c h gave the number of described species as 107, but here he has been able, by means of the ample material at his disposal, to reduce the number of valid species to 22 and adds only one new variety — a remarkable result which emphasizes the confusion which had previously existed in the group and a hint is given that further pruning may be necessary when the genus *Atlanta* is more fully investigated.

The report is mainly systematic but there are distribution maps for most of the species and the author has not burdened the text with long station-lists "because of the cosmopolitan spread of nearly all the species over all tropical oceans and of their universal clinging to the superficial layers". The results would, however, have enhanced value for the marine zoologist had it been possible to give at least the station numbers for each species in an appendix. Although the heteropods were usually found in the first few hundred metres below the surface, some deep hauls down to 5000 metres yielded specimens of *Atlanta* with shells partly or wholly dissolved. A detailed study of vertical distribution has not been attempted, and it is doubtful whether any worth-while results would have accrued from it, especially as nearly all the hauls were made with open nets.

Keys have been drawn up for genera and species, and as far as it has been possible to test them, they have proved reliable and simple to use. There is very little repetitive description and the accounts are mainly concerned with establishing the identity of the species and elucidating features hitherto imperfectly known. Such features are adequately illustrated with text-figures. The choise of medium for the plates — white drawings on a black background — is very effective for these transparent animals.

The report is concluded with general notes on phylogeny, distribution, ecology, and propagation. The author follows the orthodox view in regarding the Atlantidae (with coiled shells) as the least modified, and traces a progressive series (*Carinaria, Pterosoma, Cardiopoda, Pterotrachea, Firoloidea*) in the reduction of the shell and other gastropod features, culminating with the shell-less, tubular Pterotracheidae. He regards *Cardiopoda* and *Pterosoma* as having "their position somewhat outside the common stem." The results show that most of the species are cosmopolitan in tropical and subtropical seas. All occur in the Indo-Pacific, but five species (1 of *Atlanta*, 3 of *Carinaria*, and 1 of *Pterosoma*) appear to be absent from the Atlantic and eleven are not found in the Mediterranean. Gut contents revealed that they feed on ctenophores, salps, pelagic Hyperiidae, Euphausiacea, chaetognaths, and even other heteropods. In turn they are attacked by other animals including fish and *Sagitta*. The details of reproductive processes are still unknown for most species and the author mentions sausage-shaped objects attached to the shells of female specimens of Atlanta and believes them to be spermatophores. He suggests that the function of a large glandular process in the copulatory apparatus of the male (which is too large to be introduced into the female genital pore) is to attach the spermatophore to the shell of the female.

The memoir is a worthy addition to the Dana Reports and is indispensable to all who study the heteropods.

W. J. Rees.

S. Thore. "Investigations on the "Dana" Octopoda. Part I. Bolitaenidae, Amphitretidae, Vitreledonellidae, and Alloposidae." Dana-Report No. 33, 85 pp., 69 text-figs. Copenhagen and London, 1949.

This most interesting contribution to the fine series of the Dana-Reports is far more than a mere taxonomic study of the material submitted for investigation. The four families listed in the title are subjected to a thorough revision, with redefinitions of tribal, familial, generic, and specific characters, and the distribution of the species, both vertical and horizontal, is examined in relation to age and life history. The use of indices for the expression of bodily proportions, first introduced in cephalopod taxonomy by the late G. C. Robson, combined with a careful consideration of changes associated with age has led to a most satisfactory reduction in the number of valid species. Thus the family Bolitaenidae now contains four genera, each with a single well-established species. Thiele's two specimens of *Bolitaena microcotyla* were re-examined, although this species is not represented in the Dana collections, so that the survey of the family is complete. One new genus with a single species, *Dorsopsis taningi*, is erected for a solitary immature specimen with highly distinctive features. The three remaining families are now shown to contain but a single species each, viz.: *Amphitretus pelagicus*, *Vitreledonella richardi*, and *Alloposus mollis*. Presumably owing to wartime conditions the author did not have access to type material in foreign countries but, while this is much to be regretted, he must be congratulated on a most successful analysis of all published descriptions. For example, it was discovered that Verrill had observed and described the hectocotylus of *Eledonella pygmaea* without recognising it for what it really was.

Many points of interest emerge from the study of changes in bodily proportions with growth. For example, at least four of the species studied are bathypelagic forms with reduced or relatively small eyes. The larvae inhabit subsurface layers and have relatively larger eyes. Furthermore, the eye-diameter index provides an excellent taxonomic character for the separation of even the youngest stages of the two most abundantly represented species, *Japetella diaphana* and *Eledonella pygmaea*. Both have relatively larger eyes in young animals but the two lines run parallel, one below the other. At all stages the eyes of *J. diaphana* are approximately twice as large as those of *E. pygmaea*.

Ovarian eggs have been described wherever possible. *Bolitaena* has globular eggs like those of *Vampyroteuthis infernalis*, but smaller. The other species probably all have stalked eggs but, with the exception of *Alloposus mollis*, the adults are strictly bathypelagic and are never found in proximity to the bottom. Two types of pelagic egg masses are described and the smaller ones are tentatively compared with those of *Japetella*. It is unfortunate that no gravid females of *Vitreledonella* were taken by the "Dana", so that Joubin's discovery that the species is probably viviparous could not receive further confirmation.

A most interesting anatomical discovery is the unusual position of the stomach and caecum in *Amphitretus* and *Vitreledonella*. These organs are rotated dorsad and forward through 180° so as to lie just behind the brain.

The vertical and horizontal distribution of all species has been examined, but the most thorough treatment is given to *Japetella diaphana* which was represented by a total of over 674 specimens from all oceans. The author

has made a careful comparison of simultaneous catches by nets of different mesh and has introduced a correction for the E 300, a net of coarse mesh used extensively in deeper water. For animals under 25 mm. the catching power of the stramin nets exceed that of the E 300 by approximately 226 %, for the 25—40 mm. group by 214 %, and for animals over 40 mm. by 180 %. The necessity for such a correction will have to be taken into consideration by all future workers. After correction of the data for catching power of the net, and for specimens taken during raising and lowering, according to the procedure developed by B r u u n, the following conclusions are reached. Ninety-four percent. of the specimens of *Japetella* under 5 mm. in length were caught with 300—1000 m. wire; very young animals are most abundant just below the subsurface discontinuity layer, at about 200 m. depth. They appear to avoid both warm and cold surface waters and, at 200 m., their northern and southern limits are approximately demarcated by the 10° isotherm, while the 15° isotherm, in general, demarcates the upper temperature limits. Adults are truly bathypelagic. Somewhat similar results were obtained for the other species investigated, except for *Alloposus mollis* which is an inhabitant of the continental shelf and, like *Spirula* which was studied by B r u u n, it seems probable that it may go to the bottom to spawn. While many such facts of general interest have been elicited, the reviewer feels that greater clarity and simplification of the hydrographic correlations might have been obtained by the method of plotting distribution on temperature-salinity charts for the separate oceans in order that the water types might be more accurately characterized.

In regard to geographical distribution it may be noted that *Amphitretus pelagicus* is wholly absent from the Atlantic, except for a single specimen taken near Cape Town by the "Discovery". Also, in accordance with the fact that all species studied are inhabitants of the deep water of tropical and subtropical oceans, none have been taken from the Mediterranean, with the exception of a single individual of *Japetella* at less than 100 m. that was obviously carried in accidentally through the Straits of Gibraltar.

G. E. Pickford.

G. Thorson. "Reproductive and larval ecology of marine bottom invertebrates." Biol. Rev. Cambridge Phil. Soc., Vol. **25**, No. 1, pp. 1—45, figs. 1—6. Cambridge, 1950.

This paper is largely an excerpt from T h o r s o n's extensive paper in *Medd. Komm. Danmarks Fiskeri- og Havundersögelser, Plankton,* Vol. 4, 1946, which represents not much less than a monograph on the ecology of marine larvae. Its value lies chiefly in its broad treatment of ecological principles, centring around the following trains of thought.

Where summer is long enough and phytoplankton therefore present for several months in the year (i. e., in the tropics and in temperate regions), most marine bottom invertebrates reproduce by the formation of large numbers of eggs of small size. These may be numerous because they are so small. Because of their smallness, however, they are poor in yolk, and the larvae are therefore small and for a long period have to depend on the plankton for food. During this long planktonic life a heavy toll is levied by enemies, and the longer development takes, the heavier is the toll. As growth is influenced by the water temperature and the quantities of food available, these latter factors indirectly influence larval loss.

The large egg production of these species suits the heavy losses to which they are subjected as larvae. The numbers of eggs, however, can only suit mean conditions, whereas in reality conditions differ from year to year. All species with this mode of reproduction therefore show great fluctuations in numbers of individuals from one year to another. These fluctuations, again, are of much influence on the fauna as a whole, as they determine the quantities of plankton and other food these fluctuating species consume and the quantities of other animals for which these species serve as food.

One should realize that species with enormous numbers of eggs and those with small numbers both need the same low number of offspring to replace the parent animals. It is therefore certain that the losses in the former are always much higher than those in the latter.

Whereas in temperate and tropical regions a higher percentage of the invertebrates reproduce by the method here described (large numbers of small eggs) few representatives of this type of reproduction are found in arctic and antarctic regions, where a short summer with low temperatures would cause too slow a development and too long a larval life. Large yolky eggs or viviparity are the rule there. Thorson stresses the point that those few arctic species which do reproduce by large numbers of small eggs show a clear advantage over the viviparous and other species in so far as their numbers of individuals may be much higher than those of the latter. Though this seems a contradiction, the assumption may be right that where summers are not too short marine bottom invertebrates do better by leaving it to their offspring to feed on the plankton than by collecting food themselves for the production of large yolky eggs or living young.

These and a great many other thoughts represent the backbone of Thorson's valuable paper, in which the field of larval ecology is dealt with in a clear, original, and fascinating manner. The literature on the subject is very fully treated. The book as well as the abstract form a stimulating base for further work; ecological and ethological research on marine larvae have hardly started and Thorson's papers open wide perspectives to them.

J. Verwey.

A. Bückmann. "Die Untersuchungen der Biologischen Anstalt über die Ökologie der Heringsbrut in der Südlichen Nordsee." I. Teil. Helgoländer Wiss. Meeresunters., Bd. **3**, H. I, S. 57, Abb. 39. Helgoland, 1942.

This paper is a study of the distribution and size of the herring larvae in the southern part of the North Sea and the northern part of the English Channel during autumn and winter. The intricate and much disputed questions connected with "herring races" in the North Sea form the background for the work. Longer term investigations of this kind also aim at throwing light on the fundamental problems of possible causes of fluctuations in the strength of year-classes. The paper does not pretend to supply a solution to these questions; as the author himself says, "In der Hauptsache wird nur erreicht, dass das von Mielck entworfene schematische Bild berichtigt, im einzelnen ausgeführt und durch konkrete Befunde über die Verhältnisse bestimmter Jahre bestätigt und belebt wird". However, this ought not frighten anyone from reading the paper. For those who are directly engaged on these problems, the paper provides a valuable supplement of observations presented in an easily understood form, and those who

are not quite familiar with the specific questions here dealt with will get an intelligible picture of the present stage of knowledge regarding these interesting problems.

From a consideration of the occurrence of herring larvae with yolk sac attached, the author localized three spawning places in the southern North Sea and the English Channel. These are the Dogger Bank region, the eastern coast of England and the Downs.

In the Dogger Bank region the hatching of larvae takes place from the beginning of October to the beginning of November. The importance of this spawning place is evident from the enormous quantities of larvae encountered. Thus on 14. October 1936 at 54°35′ N. and 1°13′ E. there were found ca. 19,000 larvae under 1 m^2. of surface. The majority of these larvae had their yolk sacs. In the catch there were also considerable numbers of empty herring-egg membranes, and attached to these, unhatched eggs. Certain difficulties are experienced in following the transport of the larvae from the spawning place. Additional observations are needed to arrive at the true picture. In the main, the transport is assumed to be eastward towards the coast of the German Bight and Jutland where metamorphosis takes place in April/May.

The second spawning place on the eastern coast of England is regarded to be of less importance than the Dogger Bank area, but the material in hand is insufficient for a certain judgement. The hatching of the larvae in this region begins in September and continues to the beginning of November. The transport of the larvae is assumed to be southwards along the coast, partly eastwards towards the Flemish Bight and partly into the Dogger Bank area where the two groups of larvae mix.

The Downs spawning place, in the transition area between the North Sea and the English Channel, is of greater importance and is regarded as equal to the Dogger Bank area. Hatching takes place from the end of November to the end of January. The larvae are transported successively northwards along the eastern side of the North Sea until they seek the coast in spring and metamorphosis occurs.

The growth of the larvae is also studied. The growth analysis supports the conclusions drawn in regard to the transport of the larvae.

It is indicated in the foreword that the second part of the paper has been worked out in all essentials. If it lives up to the promise of Part I, the second part may be looked forward to with great interest. No doubt its publication will not be long delayed, as the first part appeared in 1942.

O.Aa.

W. C. Hodgson & L. D. Richardson. "The Experiments on the Cornish Pilchard Fishery in 1947—8". Min. Agric. & Fish., Fish. Invest., Ser. II, Vol. **17**, No. 2. pp. 1—21, 7 figs., 10 pl. London, 1949.

Ce travail est important au double point de vue technique et biologique.

1°) Le rendement de la pêche au pilchard (la sardine de dérive ou Celan des Français) que les pêcheurs de Cornouaille britannique pratiquent avec les filets droits dérivants peut-il être amélioré?

Les auteurs ont répondu de manière positive à cette question. Par emploi conjugué d'appareils de détection sous-marine (sondeur à ultra-sons ou même simple fil détecteur) et du filet tournant ils ont démontré que la grosse sardine est abondante dans les eaux du sud-ouest de l'Angleterre et qu'elle peut y

être pêchée industriellement (des captures de plus de 13 tonnes ont été réussies). Les enregistrements des échos fournis par les bancs de poissons, qui illustrent le texte montrent l'excellence de l'appareil utilisé (Hughes M. S. XII) et tout le parti qu'on peut tirer de cette nouvelle technique.

2°) A cette étude technique font suite des observations d'ordre biologique.

Rappelons que l'on a toujours considéré jusqu'ici que le peuplement de la région prospectée est assuré par des sardines de grande taille, âgées de plusieurs années et que l'absence des jeunes de moins de trois ans constitue le problème majeur que les chercheurs s'efforcent de résoudre. Cette absence a donné lieu à plusieurs hypothèses; suivant la plus récente les jeunes passeraient leurs premières années dans les eaux plus chaudes du sud, le long des côtes de France.

Les pêches pratiquées au filet tournant à mailles plus petites que le filet droit et le chalut, ont fourni aux experimentateurs la preuve que le clavier des groupes d'âge est plus large qu'on ne le supposait. Il commence au groupe II et s'étend jusqu'au groupe IX. Par contre les sardines de moins de deux ans semblent bien faire défaut et si le problème posé plus haut se restreint désormais aux seuls groupes 0 et I, son importance reste grande.

Aux tailles de 18 à 24 cm. observées en Novembre 1947 correspondent des âges de 2 à 9 ans. La rapide décroissance de la valeur numérique des groupes de plus de 5 ans suggère aux auteurs qu'après cet âge une forte mortalité se produit et que la sardine, par conséquent, a une vie relativement courte. Ces observations renouvelées en 1948 leur ont permis de constater que, dans l'intervalle, les sardines ont complété un hiver physiologique, les groupes de pointe II et V devenant les groupes III et VI. Ils en concluent qu'il est possible de faire des prévisions sur la constitution future du stock local.

En 1948 toutefois, les sardines de deux ans qui, 8 à 10 mois plus tôt, étaient pourtant les plus nombreuses n'ont pas été retrouvées. Elles ont pu échapper aux investigations mais peut-être aussi ne se tenaient-elles pas dans cette région. Et cette absence signifierait alors que d'une année à l'autre la composition des bancs peut subir de profondes modifications, tout au moins en ce qui concerne les jeunes classes. En effet, on a peine à croire qu'entre les différents groupements de la Manche et du sud de la Mer du Nord qui, certaines années, n'offrent aucune discontinuité, il n'y ait pas des échanges plus ou moins massifs.

Les auteurs fixent l'âge de la pleine maturité sexuelle à 36 mois environ et constatent que les individus les plus âgés présentent en Novembre une grande variété dans leurs stades évolutifs (depuis I—III jusqu'à la ponte et la ponte accomplie). Ils établissent une corrélation entre ce phénomène et la grande amplitude de la valeur L_1 qui varie entre 4·5 et 11·5 cm. confirmant ainsi l'existence, plusieurs fois contrôlée, d'une longue saison de ponte étalée sur le printemps, l'été, et l'automne.

Mais ceci prouve-t-il que l'évolution vers la maturité sexuelle se fait, pour toutes ces sardines *in situ*? La diversité des stades de maturité, de même que celle des valeurs L_1, pourrait, nous semble-t-il, aussi bien être attribuée, au moins partiellement, à des apports successifs de sardines provenant d'autres secteurs plus occidentaux ou méridionaux.

Une intéressante corrélation est aussi relevée entre le nombre de vertèbres et la taille des poissons. Rappelons encore que cette corrélation déjà observée chez les sardines du Golfe de Gascogne a permis de tirer certaines conclusions sur les déplacements de ces clupes.

En fin de saison la teneur en graisse des sardines de Cornouaille est très

élevée — 16 % du poids total du corps chez les adultes et 20 % pour les immatures. La qualité de cette condition comparable à celle des sardines du Maroc et du Portugal, liée sans doute au cycle sexuel l'est surtout au cycle du plancton, lequel devait être particulièrement favorable en 1947 et 1948.

Enfin Hodgson et Richardson ont remarqué grace à leur sondeur ultra-sonore que la composition des bancs de pilchards peut varier fortement d'un point à un autre de la côte, les jeunes se tenant plus près du rivage que les adultes, et que les bancs peuvent être nombreux et d'un petit volume ou au contraire isolés et massifs. Ils ont constaté aussi que les pilchards peuvent monter à la surface si on leur lance de l'appât et que la lumière semble les attirer (particularités depuis longtemps utilisées par les pêcheurs du sud).

Enfin, la sardine, différant en ceci du hareng, se déplace toujours avec le vent et peut être considérée comme un poisson "de dérive". Tenant compte de cette dernière caractéristique, ils pensent avec raison que l'étude de la circulation des eaux de la Manche occidentale peut conduire à la découverte des lieux où se tiennent les jeunes issus des pontes locales qui s'en vont peut-être jusqu'aux côtes françaises.

Mais il est un facteur — la température — sur lequel l'attention des auteurs doit être attirée car il détermine toute la biologie de la sardine. Partout discernable, son rôle est surtout évident aux limites de l'habitat de l'espèce où ses variations toujours plus brusques et plus fortes provoquent de la part du poisson des réactions toujours plus nettes. Or la Manche (et le sud de la Mer du Nord) se situe aux confins nord de cet habitat. L'étude conjointe des variations de la température et de celles de la morphologie et de la biologie du pilchard devrait leur permettre de régler la question toujours controversée des migrations de ce clupe.

Jean Furnestin.

Ralph P. Silliman. "A study af variability in plankton townet catches of Pacific pilchard (*Sardinops caerulea*) eggs." Journ. Mar. Res., Vol. **6**, No. 1, pp. 74—83, figs. 22—23. New Haven, Conn., 1946.

Although plankton nets have been in use for quantitative sampling for over 60 years, there is still remarkably little precise knowledge on the relative efficiency of different types of gear. It is therefore always good to see new studies on this subject, and Silliman and Winsor and their colleagues have in recent years made several valuable contributions. The paper under review analyses the variance of pilchard egg counts from duplicate laboratory samples from paired oblique hauls, at each of 24 separate stations from pilchard egg surveys. It is found on the basis of sampling variability alone that the count from a single haul was significantly different from another (using the 20 : 1 chance level) if it was less than one half or more than double the other. However, the part of this paper which is of most general interest to the worker comparing total egg production from area to area or season to season is that which deals with the estimation of fiducial limits of mean values derived from different numbers of stations.

Most of the statistical studies of plankton data, like the present paper, consist of analyses of results obtained during surveys. In addition to such analyses as these, there is great need for statistical studies to be carried out before the surveys are made, with the specific aim of determining the most suitable layout of stations, the best gear to be used for the particular survey, and the best technique of analysing the data. The need for this is indicated in Silliman's paper where he points out that Winsor and Walford,

using vertical hauls, obtained a smaller "co-efficient of variation" than was obtained using oblique hauls, and presumes that this was due to the pairs of vertical hauls being nearer together spacially than were the pairs of oblique hauls. Similarly, the author mentioned that a flow-meter was used in the mouth of the townets, but he shows that the differences between the paired hauls were not reduced by adjusting the values by the flow-meter readings. This result is very surprising, for even under the best of conditions (which so rarely persist throughout a survey), it is very difficult to ensure that paired hauls, and especially oblique ones, filter identical amounts of water. In fact it would seem likely that flow-meters, provided they do their job properly, will become an accepted part of quantitative plankton technique.

A. C. Simpson.

G. Dannevig. "The Biology of Salmon from Southern Norway: Fluctuations in Age and Growth." Fiskeridirek. Skr. **9**, 5, 48 pp. Bergen, 1949.

This paper is based on collections of scales and statistics of catch of salmon from four places on the Skagerak coast of Norway. From 1922 to 1939 1840 salmon from the River Nidelven were examined. Less extensive material (473 fish) from the river Tovdalselven and from two coastal bag-net stations, Arendal (411 fish) and Flekkefjord (125 fish), is also described. Naturally the Nidelven data provide most of the information but the other stations provide a useful check, particularly as there appears to be no great difference between the stocks sampled at the various places.

Most of the fish had spent three years in the river before migration, though there were a considerable number of two-year-old smolts. Most of the fish returned to the coast and the rivers after two years of sea life, but grilse (fish with one year of sea life) were also common. Older salmon were scarce. There were great annual fluctuations in the proportion of grilse and small salmon, but from the figures it did not appear that a good grilse year was followed by a good year for small salmon, and the author concludes, therefore, "that salmon do not always stay for the same period in the sea: in some years they enter the river in the grilse stage and in other years they spend another winter in the sea." Hutton and others who have investigated the salmon of the Wye concluded that a good catch of grilse in one year was generally followed by a large run of small salmon the next year. That implies that in some years, at any rate, abundant grilse are evidence of an abundant year-class, which will be present in the fishery for the next two years. Dannevig does not find that the persistence of the year-class was a factor of great importance, for in the stocks he investigated any year-class was important for two years only.

He confirms the finding of previous observers that a long period of river life tends to be followed by a short period of sea life, but in general he concludes that the length and weight of the salmon are not influenced by the duration of river life. He finds great annual fluctuations in the size of grilse and small salmon and points out that the fluctuations in growth are most marked during the first year of sea life. He also finds that where growth in the first year of sea life is calculated for the same year, salmon of different ages exhibit corresponding variations. The growth seems to be more rapid in years with a high temperature in the surface waters along the coast than in years with a low temperature. These variables, he points out, may or may not be related directly; they may be due to some common cause.

This observation is of great interest, it could be used to support Huntsman's theory that salmon never normally leave coastal waters, at least in their first year of sea life, but, of course, there are other explanations.

This paper is clearly a progress report; it does not attempt to integrate these observations with those made in other parts of Norway, or in other countries, but nevertheless it is interesting for the wealth of data presented and the careful conclusions drawn from them. It is particularly valuable because the data are given *in extenso* in a series of appendix tables, a practice which greatly enhances the value to the serious student of any publication, but one which we have had to forego in the interest of paper economy.

Figure 2 of this paper is a startling and depressing graph of the catch of salmon in the two rivers from 1880 to 1938. It shows a catastrophic decline, but to this the author makes no reference, although such a phenomenon would seem worth at least a passing word. Finally a word of criticism must be directed at the text figures. Their lettering is dreadful and your reviewer found it impossible to decipher them without the aid of a reading glass.

F. T. K. Pentelow.

J. W. Jones. "Studies of the Scales of Young Salmon, *Salmo salar* L. (juv.) in relation to Growth, Migration and Spawning." Min. of Agric. and Fish., Fish. Invest., Ser. 1, Vol. **5**, No. 1, pp. 1—23, 5 figs. London, 1949.

The author has examined a great number of parr and smolt scales from British rivers, mainly from the Cheshire Dee (1500 fish) and the Wnion, Dolgelly (500 fish), but also from other rivers ranging from Devon to Caithness.

His research has confirmed that the seasonal growth-rings usually named summer and winter rings, really are formed during the summer and winter respectively. In the Cheshire Dee the author has found a slight growth throughout the winter in the salmon parr.

In the scales from the Cheshire Dee, partly also from other rivers, Jones found two types of summer rings forming the second summer band, wide rings being formed in the early summer, narrow ones in the late summer and autumn. This seems to correspond well with Allen's observations from Eden and Thurso, where the growth in the parr appeared to be rapid in the early summer, slow in the latter part of the summer.

Counts of growth-rings of two-year-old parr from various rivers did not reveal variation sufficient to characterize distinct types, except in the river Teme, where the number of seasonal rings was particularly high.

The author has stated that younger migrants have a faster growth than the older migrants, and, correspondingly, that the age at migration is to be related to the rate of growth. The spawning of the male salmon parr was not reflected in any way on the scales. Spent males were predominant amongst the three-year-old migrants, whereas females predominated amongst younger migrants.

The scale samples were all taken "on the shoulder of each fish". The author has certainly not been aware of a paper by Dannvig and Høst ("Sources of Error in Computing l_1—l_2 etc. from Scales taken from Different Parts of the Fish." *Journ. du Cons.*, Vol. VI, No. 1, 1931), stating that the l_1 may disappear in scales from the pectoral region, anyway in northern

waters. Why do all British fishery biologists continue to sample scales from the shoulder of salmonida, thus running the risk of losing the first year in their reading?

Sven Sømme.

T. H. Järvi. "Sea Trout in the Bothnian Bay (*Salmo trutta*)." Finlands Fisk., Vol. **15**, 29 pp., 8 figs. Helsinki, 1940.

In this work, the author discusses some observations concerning the size and rate of growth of the sea trout which ascend the rivers Kemi and Kokemäki. The ascent takes place partly in the early and partly in the late summer. The majority ascend after three to four years at sea. At the beginning of the ascent, the ovaries have somewhat incompletely developed eggs. It is only during the ascent that they acquire their extra food reserves. The rate of growth was studied partly by direct observation of the length and weight of the fish, the age of which could be determined by counting the number of growth zones on the scales, and, partly, by use of the Dahl-Lea method.

According to the results of the direct method — numerically insufficient, unfortunately — the length of the fish increased during the second, third, and fourth years in the sea by 8·63, 13·14, and 9·34 cm. respectively. Weight increased by 0·42, 1·2, and 1·3 kg. respectively. According to the results of the indirect method of measurement (which seems to have been used without the necessary corrections and which, therefore, may not be completely reliable) the corresponding length increases should be 14·7, 12·9, and 8·1 cm. respectively. In the opinion of the author, it is of only minor importance to the rate of growth in the sea how long the fish spent in the river before emigration. The duration of this period, however, seems to depend on whether the fish grows quickly or not. At a medium rate of growth, migration takes place at about four years of age and at a length of about 20 cm. Thus, the average migration age in these northern areas is higher than in the Finnish bay, the Stockholm skerries, and the waters of the southern Baltic, whence, according to Segerstråle, Alm, Hessle, and others, sea trout normally migrate at the age of two or three.

E. Dahr.

T. H. Järvi. "Über den Maränenbestand in Pyhäjärvi (SW.-Finnland)." Finlands Fisk., Vol. **14**, pp. 86, 42 figs., 1 chart. Helsinki, 1940.

T. H. Järvi. "Zur Kenntnis der Coregonen-Formen Nord-Finnlands, insbesondere des Kuusamo-Gebietes." Finlands Fisk., Vol. **18**, pp. 91, 53 figs. Helsinki, 1943.

As long ago as 1928 the author published a comprehensive work on forms of *Coregonus* in a number of Finnish freshwater and coastal areas. Here, the location and growth conditions of various forms of *Coregonus* were especially dealt with. The author based his conclusions, rather one-sidedly, on the number and length of the gill rakers, thus following the lead of Nüsslin and Thienemann. He thus reached the conclusion that "the old generic species *Coregonus lavaretus* is divided into several separate species or form groups." He found at least eight such species in Finnish waters and believed himself able to classify them in the main groups *C. fera, holsatus, lavaretus, wartmanni, generosus,* and *macrophthalmus* in accordance with the classification system established for the Central European alpine areas.

In his report on northern Finland's *Coregonus* species, published in 1943, the author abandoned this nomenclature. He has thus come into line with the systematic views expressed by the Russian ichthyologist B e r g and he has paid more regard to factors other than the appearance of the gill rakers, the region of occurrence, for instance. Instead, he now establishes three main groups. *C. pidschian*, related to the *Coregonus* species of the Arctic and White Seas; *C. lavaretus*, related to the Baltic species; and *C. muksun*, with eastern connexions. Although the occurrence of these types is greatly influenced by transplantations, the appearance in different lake systems of the three species seems, at least in certain areas — for example, the very thoroughly investigated Kuusamo area of north-eastern Finland — to reflect their migration from the north-east, the south-west, and east respectively.

The growth conditions have been studied by employing the D a h l - L e a method, on the supposition that the annual length increment is directly proportional to the relative breadth of the corresponding increment of the scale, although corrections must be made in the form of certain additions to the length of the body, following a sliding scale. In his previous work, the author had arrived at the conclusion that with regard to rate of growth, the various forms could be classified in different groups:— fast growing (*C. lavaretus f. typica*); medium (*C. fera, holsatus, generosus f. aspia*); and slow growing (*C. wartmanni, macrophthalmus*). Further forms with marked dwarf growth are found (*C. wartmanni f. borealis, C. lavaretus f. lapponica*). In his 1943 work, the author firmly maintains that the rate of growth depends largely on external conditions. The size of *Coregonus* in a lake yields more information on the nature of the water than on the systematic position of the *Coregonus* forms.

In his 1928 work, the author devoted a separate chapter to the *Coregonus* forms in the Pyhäjärvi Lake, a large lake in south-western Finland. These forms are of special interest, since they originate entirely from transplantation material, namely, *C. lavaretus*, partly *C. muksun* (= *generosus*). In this way the author has now, to some extent, been able to study the rate of growth of the various forms concerned and this led him to the conclusion that there is no possibility of using the different rates of growth as a distinctive character in distinguishing the various forms of *Coregonus*. In the various forms of *Coregonus* from Pyhäjärvi the growth-rate of the individuals did not differ from the general trend of the growth-rate. "The factors that increased the rate of growth have worked in the same way on *Coregonus* with densely as well as thinly raked gill arches."

Of importance to the rate of growth, however, is not only the nature of the environment and its casual changes, but the relative abundance of the various year-classes of fish has also proved to be a decisive factor. A poorly populated area produces a faster rate of growth than one more densely populated. When a particular age-group is numerically great, the rate of growth of that age-group is higher. This observation regarding *Coregonus* is in line with the conclusions which the author has reached in his work on the vendace (*Coregonus albula*), regarding the growth conditions of this species.

E. Dahr.

T. H. Järvi. "Die Bestände der kleinen Maränen (*Coregonus albula* L.) und ihre Schwankungen. 1. Pyhäjärvi (Südkarelien)". "2. Ober- und Mittel-Keitele." Finlands Fisk., Vol. **16**, 89 pp., 15 figs. Helsinki, 1942: Vol. **17**, 145 pp., 22 figs. Helsinki, 1942.

T. H. Järvi. "Über den Kleinmaränenbestand (*Coregonus albula* L.) in dem See Vesijärvi." Finlands Fisk., Vol. **19**, 43 pp., 5 figs., 3 charts. Helsinki, 1947.

The author has, in previous works, thoroughly dealt with the important factors of the biology of the vendace, from various angles, in a number of Finnish lakes. In the above papers he has turned his attention to the periodic appearance of the species in the lake systems named in the titles and to the reasons for these occurrences. The author had no access to reliable statistics on quantities of fish caught in the Keitele lakes, and has had to base his conclusions on information relating to spawn yielded in 1907—1941. As far as the Pyhäjärvi lake is concerned, fishermen's records of catches in the years 1907—1922, with average weights of the fish, have been at the author's disposal. The age composition of the catches, however, he has studied by analysing samples (of about 10 kg. each) taken during the years 1913—1920. For the Vesijärvi lake the investigation was based on rather small samples. The author maintains that good and poor annual yields coincide during the whole period 1913—1920 in the last two lakes. The spawning season starts at the same time in both of them (November) while it starts in October in the Keitele lakes. The bulk of the catches consisted of fish of two to three summers old. The analysis of the age compositions is accompanied by information of the rate of growth, obtained by scale examination.

The author tries to find a correlation between changes in the catches and the weather conditions at both spawning and hatching time, for the more important year-classes. He believes that a positive correlation can be shown to exist between an abundant year-class and calm weather, especially while fry are hatched and scatter, and concludes that windy weather during these periods constitutes one of the most important direct or indirect causes of numerically weak year-classes. One of the author's many interesting observations is that the growth of the vendace is influenced by the density of the stock, rate of growth being lower for densely populated areas and higher for lightly populated areas.

E. Dahr.

A. Määr. "Über die Aalwanderung im Baltischen Meer auf Grund der Wanderaal-Markierungsversuche im Finnischen und Livischen Meerbusen i. d. J. 1937—1939." Medd. Stat. Unders.- och försök. sötvatt., Nr. **27**, pp. 56, Tab. 1—10, 2 figs. Stockholm, 1947.

A. Määr. "The Migration Speed of Silver Eel (*Anguilla vulgaris* L.) in the Baltic." Apophoreta Tartuensia, pp. 421—427. Stockholm 1949.

During the years cited the author marked and liberated a total of 882 eels caught during the migration period (September) in Esthonia. Most of the eels were liberated at various places along the Esthonian coast, but a minor portion was transported to Finland to be liberated in Finnish waters on the northern coast of the Gulf of Finland. Of the latter, 43 specimens were liberated in the waters west of Kotka (1938) and 115 in Viborg Bay. Of the eels marked, 157 specimens were recovered, i.e., 17·7 %. Of the eels

liberated in Esthonia 70 specimens were recovered in Esthonia, 39 in Sweden, 13 in Denmark, 8 in Germany, 1 in Latvija, and 1 in Poland. Of the marked eels liberated in Viborg waters 16 specimens were recovered in Esthonian waters, 6 in Sweden, and 1 in Denmark, while one specimen only of the eels liberated in Kotka was recovered — in Sweden. The 16 eels liberated in Viborg Bay and recovered in Esthonia show that they migrated mainly west-south-westward and that they travelled from the northern coast of the Gulf of Finland across the sea to the southern coast of the western part of the gulf.

Thus the western parts of the Finnish waters may constitute the original waters from which come the eels travelling along the northern coast of the western part of the gulf (the route determined from previous markings initiated by N o r d q v i s t and P a l m é n). In crossing the Baltic Sea the eels followed their main route, some travelling south of Aaland's Haf, some from Irben Bay to Gothland, and others from the eastern coast of the southern part to the waters of Rügen Island. The author having considered the various factors influencing migration concludes that possibly the main direction of migration is due to the positive taxis the eels bear to seismic phenomena; in this opinion he therefore reverts to A n d r i a s c h e f f's conception presented in 1944 concerning the sensitivity of eels to these phenomena.

T. H. Järvi.

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Prepared by the Editor with the Assistance of Mr. A. C. Simpson.

NOTE. The scope of the Bibliography is limited in the main to the area covered by the Council's activities, but there are included papers of general interest relating to other areas in North Temperate and Arctic regions and exceptionally elsewhere. Limnological references are not as a rule given, but papers relating to brackish waters and to salmon and freshwater fish studied by the Council are included.

Subscribers and those on the distribution list will receive regularly upon application to the General Secretary copies of the Bibliography printed on one side of the page only, for use in making up card indices.

The Editor will be glad to be advised of emendations and additions to the Bibliography.

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